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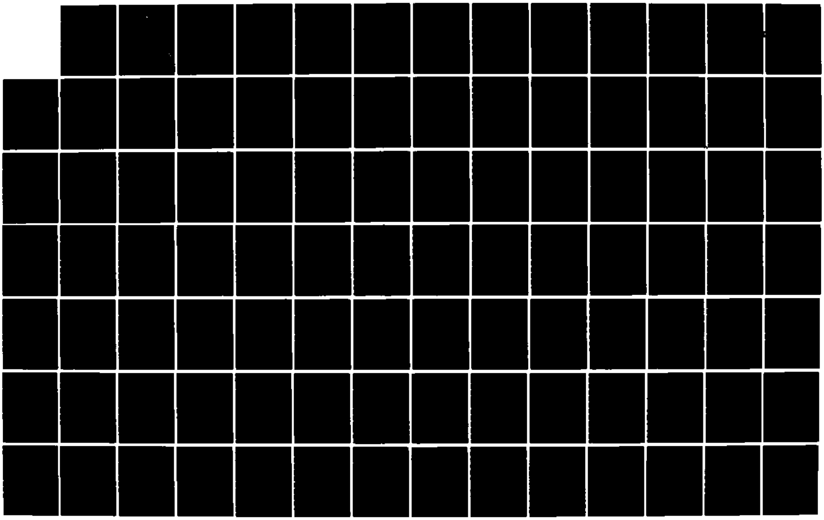

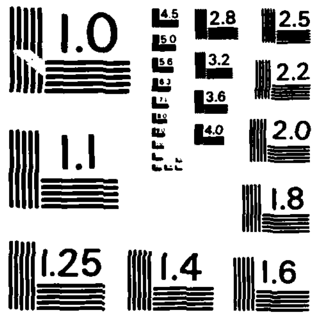
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A SIMULATION MODEL TO MEASURE THE EFFECT AN IN-THEATER STAGING BASE HAS ON ECONOMIC ORDER QUANTITY ITEMS AT A FORWARD OPERATING BASE

THESIS

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A SIMULATION MODEL TO MEASURE THE EFFECT AN IN-THEATER STAGING BASE HAS ON ECONOMIC ORDER QUANTITY ITEMS AT A FORWARD OPERATING BASE

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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Preface

The purpose of this thesis effort was to develop a simulation model to represent a staging base system and to assess the system's capability of effectively supporting a Forward Operating Base (FOB). The model was designed to simulate resupply actions of an FOB for Economic Order Quantity (EOQ) items after sixty days of a limited war. The staging base concept is centered around a staging base which is located near the FOB but not subject to hostilities. A similar model was designed to simulate the resupply actions of the current resupply system in which the FOB orders its EOQ supplies directly from the continental United States (CONUS). Output from both models was compared in terms of the FOB mean reorder time, mean time out of stock, mean number of reorders, and mean number of times out of stock in order to determine which system was more advantageous for the FOB to use. The results favored the staging base concept in supplying EOQ items to the FOB. Further study in this area should include using reparable and equipment items since favorable results for these items could prove to be of even greater value.

The authors of this thesis effort wish to acknowledge those individuals whose assistance aided us in reaching our goal. It is with deep admiration and great respect that we thank our advisor, Mr. Patrick M. Bresnahan. His timely guidance, keen insight, and boundless faith in us was the catalyst without which we could not have succeeded. We are

also indebted to Mr. Warren Barnes, who, as our reader, provided us with the objectivity that is so vital to a project of this magnitude. But most of all, we owe so much to our wives, Beth and Beverly, and our children for their love, care, and understanding which held our families together during this most trying year.

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Abstract

During a limited war a theater commander will need a resupply system to support his Forward Operating Bases (FOB). Because the limited war will probably not provide sufficient notice to build up forces and supplies, it will be fought in a "come as you are" scenario. This scenario is compounded by the declining industrial base and the high cost of limited materials used by today's fighting forces. The scenario is further compounded by long shipping times from the continental United States (CONUS) resulting from the limited availability of cargo aircraft. This causes the majority of all sustaining supplies to be shipped by sea. Since the probability of lateral support and air superiority can not be assumed, the success of combat operations at the FOB will rely heavily on timely resupply.

The staging base concept enables the FOB to order supplies from a staging base instead of the CONUS. The staging base would be located in the same theater or near the FOB but would not be subject to hostilities. This study simulated the resupply actions for Economic Order Quantity (EOQ) items ordered by an FOB from the staging base and compared results with ordering from CONUS. The indicators measured at the FOB were the mean reorder time, mean out of stock time, mean number of reorders, and mean number of times

out of stock. The results revealed both similarities and differences in the two systems. One major difference was the mean out of stock time. Analysis showed the staging base concept provided the FOB with an out of stock time that was, at times, one half that of the current resupply system. Recommend this study be expanded, to include reparable and equipment items, in order to document the effectiveness the staging base concept may provide to other types of assets.

A SIMULATION TO MEASURE THE EFFECT AN IN-THEATER STAGING BASE HAS ON ECONOMIC ORDER QUANTITY ITEMS AT A FORWARD OPERATING BASE

I. Introduction

Issue

The question posed by Headquarters, United States Air Force (HQ USAF) is: What effect would the establishment of an in-theater staging base have on stock replenishment for a Forward Operating Base during a limited war? (3:1). HQ USAF would like to establish an in-theater staging base during a contingency to reduce the pipeline for repair and replenishment if research in this area proves favorable. HQ USAF believes that our current procedures result in a resupply pipeline that is too long and inflexible to the needs of the combat commander. They also believe that our current procedures are inadequate because of the growing demand for rapid resupply. General James P. Mullins, Commander, Air Force Logistics Command has stated "the key to our having an essential military capability is logistics; for, ultimately, the limiting factor on what any military force can do depends on its logistics support" (14:2). In providing the best support to our wartime forces, resupply procedures need to insure force sustainability and survivability through rapid replenishment channels which are flexible, shorter in length, and guarantee a continuous flow of materiel.

Qualities of a Rapid Resupply System

The goal of any logistics system, especially a rapid resupply system, is to sustain forces by providing the means for fighting wars (1:3-5). The components of a rapid resupply system, that will lead to the accomplishment of this goal, must possess the qualities of adaptability, responsiveness, survivability, reliability, and flexibility.

In providing adaptability, the rapid resupply system "must be capable of changing as the environment in which it operates changes" (1:3-6).

> The changes that we make in the logistics system generally affect the way we process resources rather than the basic attributes of the system. The changes can range from major policy changes to the introduction of new methods, but they usually take some time to implement, and are designed to help the system operate better in the long term. (1:3-6)

Adaptability, a dynamic characteristic, will insure force sustainability and will provide the lifeline to survivability. Responsiveness of a rapid resupply system involves the capability to meet mission support requirements quickly and accurately. "Aerospace forces must be capable of reacting rapidly, with a wide range of options, to crisis and armed conflict. The responsiveness of the logistics system is the key element of this capability" (1:4-15).

> Logistics commander structures must be developed in peacetime to allow commanders the best possible control of resources--personnel, materiel, energy, and information--not only under normal conditions, but in crisis and under the stress of war. (1:4-15)

In possessing survivability, the rapid resupply system must

promote a continuous, uninterrupted level of support to our wartime forces. Planning, a key factor in this area, insures that primary resupply methods are backed up by alternate methods which will take into account sustainability of our forces. In being reliable, the resupply system will perform as required without failure throughout the length of a crisis or conflict. Reliability infers a system that can be depended upon to provide the proper items, in the proper quantity, at the proper time. The flexibility of a rapid resupply system entails the capability of meeting support requirements quickly and economically. "The Air Force must be able to carry out its assigned responsibilities at every level of conflict, carry out a variety of missions rapidly, and move quickly from one course of action to another" (1:4-10). The rapid resupply system must be designed to inherently support flexibility in mission requirements by itself being flexible (1:4-10).

Problem Statement

The problem statement as defined in this thesis is to determine if a forward operating base (FOB) should requisition economic order quantity (EOQ) items directly from an in-theater staging base or directly from the CONUS in order to provide for more rapid resupply.

Research Objective

The objective of this analysis is to develop a simulation model that will measure the effect the

establishment of an in-theater staging base has on an FOB as compared to our current resupply system for prolonged conflicts. The model will be designed to assist in decision support processes involving the establishment of an in-theater staging base. It will access the support effectiveness the in-theater staging base will have on the FOB regardless of the FOB's location. The support effectiveness will be determined by identifying any significant difference between: (1) the mean FOB reorder time with and without a staging base and (2) the mean FOB out of stock time with and without a staging base. A significant reduction in the FOB reorder time and out of stock time with the use of an in-theater staging base would support the establishment of the staging base.

Definition of Terms

Economic Order Quantity. An economic order quantity is defined as:

> An annual buy quantity for stockage list items which considers the cost to order as related to the cost of the item. A quantity of material established for each item based on mathematical formulas or tables, which relates the variable cost to hold material versus variable cost to buy for the determination of a balance optimum order quantity representing a minimum total variable cost. (6:246)

Forward Operating Base/Location. A forward operating base/location is defined as:

> An airfield used to support tactical operations without establishing full support facilities. The base may be used for an extended period of time. Support by a main operating base will be required to provide backup support. (6:306)

In-Theater Staging Base. A Standard Base Supply System (SBSS) located at an existing base not subject to hostilities (3:1). The staging base would be established after forces had been deployed to the FOB. Preselected stocks of items would be moved to the staging base to be in place by D+60. At D+61, requisitions from the FOB would be sent to the staging base and the staging base would perform the following actions: (1) fill the requisition, (2) check for lateral support if the item was not on hand, and (3) backorder the item from the continental United States (CONUS) source of supply if the item is neither on hand or available through lateral support. The staging base would assign all requisitions for the FOB with a special identifier code and would notify the FOB of the status and action taken on each requisition. Shipments from the CONUS source of supply would be sent to the FOB through the in-theater staging base. All billing and finance action generated by the FOB would be sent to the staging base for processing (3:6). All follow-ups for the FOB would be routed to the staging for status. Also, if it is desirable, the staging base could provide a certain level of aircraft maintenance capability and stock reparable assets for the FOB.

Limited War. A limited war possesses the following general characteristics:

> (1) Political primacy and control over the military instruments; (2) Limited objectives; (3) Economy of force and proportionality of means to limited objective; (4) Voluntary, self-imposed rules of conflict, the most prominent of which

are: (a) Communication between belligerents and the development of explicit and implicit rules of conflict, (b) Avoidance of direct superpower confrontation, (c) No nuclear weapons, or tactical and/or theater nuclear weapons, (d) Invocation of claims that the conflict is legally permissible and collectivization of the war, (e) Limited mobilization, (f) Restraint in the use of the psychological instrument, (g) Fight and negotiate strategies, (h) Introduction of third-party mediators and inspectors; (5) involvement of international organizations. (15:64)

Order and Shipping Time. "The time elapsing between the initiation of stock replenishment action for a specified activity and the receipt by that activity of the material resulting from such action" (6:497-498). The order and shipping time, composed of two distinct elements - order time and shipping time, represents the time interval in days between the initiation of a stock replenishment action and receipt of the material (6:498).

Pipeline. "In logistics, the channel of support...by means of material or personnel flow from sources of procurement to their point of use (6:522).

Pull. This term is used to denote supply systems or procedures whereby the user initiates an order for each item specifying the quantity desired.

Push. This term is used to denote supply systems or procedures where predetermined quantities of an item are automatically shipped to the user without the user having initiated an order for the item.

Assumptions

The following assumptions apply throughout the analysis

and provide a basis for model simulation:

1. The location of the in-theater staging base would not be subject to hostilities directly related to combat operations at the FOB. This is assumed primarily because the conflict is a limited war and the enemy would not expand engagement beyond the immediate area of the conflict. This assumption would allow the assets at the staging base to be survivable and enable the FOB to have a reliable source of supply.

2. The conflict would be a limited war. This would prevent the over-run or destruction of the staging base and its assets because of expansion of the war into other theaters of operation. In essence, the conflict would be geographically confined without direct superpower confrontation and the use of nuclear weapons (15:64).

3. The limited war would be of rapid movement, both retreat and attack, without having air superiority. This would require a resupply system that would keep losses of assets at the FOB to a minimum if attacked by enemy forces.

4. The in-theater staging base would be operational after D+60. This method of operation would require assets to be pushed in to the FOB for the first sixty days, i.e. war readiness spares kits (WRSK) and combat follow-on spares support (CFOSS), and would enable a demand for assets to be established on actual consumption rates. After D+60, supply support for the FOB would become the sole responsibility of the in-theater staging base. The staging base would provide for all the logistical requirements of the FOB from the 60 day point and beyond.

5. The forward operating base's Economic Order Quantity (EOQ) with the resulting Order and Shipping Time (O&ST) are assumed to be priority stock replenishment so the EOQ is therefore shipped on a priority basis. This allows the O&ST from the CONUS to the staging base during peacetime priority shipments to be measured for use as a data base in the simulation model.

6. The EOQ items on backorder are assumed to be shipped on a higher priority than those of normal stock replenishment. This allows the

O&ST of the normal priority items to be used as a basis for the simulation of the O&ST for priority items from the staging base to the FOB.

7. The distance from the CONUS to the staging base is greater than the distance from the staging base to the FOB.

Constraints

In addition to the assumptions, realistic constraints are apparent in the rapid resupply system.

> Inadequate spares availability may make item managers reluctant to move portions of their stocks to a storage location not under Air Force Logistics Command (AFLC) control. Storage space may be a limiting factor at some...locations. Adequate personnel will be difficult to find, and the assurance of adequate airlift capability, both inter and intra-theater, will be hard to secure. In addition, initially there may not be enough mobile supply computers to support large-scale operations. (21:25)

Problems may also be arise in the area adequate spares support. For example, while U.S. forces in Europe normally maintain spares and munition supplies to sustain combat for sixty days, our allies only have anywhere from seven to thirty days of stock (24:80). In order to continue fighting in that theater, our stocks may have to be distributed among our allies, thus lessening our ability to sustain combat for sixty days. However, none of these constraints is so overwhelming as to suggest that implementation of a rapid resupply system is impossible (21:25).

Research Questions

To achieve the objective of this research it is

necessary to answer the following research questions:

1. If an in-theater staging base is established, are there any significant differences for an FOB ordering from the staging base compared to an FOB ordering from CONUS in terms of order time, stock out time, number of orders and number of stock outs?

2. What is the sensitivity of the FOB operating with a staging base to changes in (1) the availability of lateral support, (2) the shipping time to the staging base, (3) the shipping time to the FOB, (4) the probability of interdiction at the FOB, and (5) changes in demand at the staging base?

Investigative Questions

The following investigative questions will be answered for an in-theater staging base:

1. How will the order and shipping time between the CONUS and the staging base be determined?

2. How will the order and shipping time between the staging base and the FOB be determined? with and without backorders?

3. How will the order and shipping time between the CONUS and the FOB be determined?

4. How will the initial stock levels, safety stock, EOQ quantity, and the reorder point be calculated?

5. How will the demand data for the items being simulated be obtained?

6. How sensitive is the mean FOB reorder time and the mean FOB out of stock time in relation to changes in demand?

7. When will the staging base or FOB initiate a stock replenishment action?

8. What are the daily demand rate, ordering cost, holding cost, and item cost for the EOQ items to be used the the simulation?

Summary

This chapter has focused on the idea of whether a forward operating base should requisition EOQ items through a staging base or directly from the CONUS in order to provide the best supply support. Specific research and investigative questions were developed to give direction to this research effort. The following chapter will review recent literature on this subject.

II. Literature Review

Historical Precedents

Clausewitz once defined the concepts of strategy and tactics: "Tactics is the art of using troops in battle; strategy is the art of using battle to win the war" (16:21). Logistics, then is the art and science that makes both tactics and strategies attainable (16:21). The dominance of logistics over tactics and strategy has been demonstrated in past wars. The general level of fighting in the North Africa campaign during World War II was regulated by logistics when the Allied advances were stopped because the ability of the logistics system to provide resources in required quantities was exceeded (16:21). Operations could be resumed only when the logistics system had collected sufficient quantities of resources to sustain further advances (16:21). Similar logistics problems were encountered by the Germans in the same region. The Japanese demonstrated their inability to reconstitute forces by losing the Battle of Guadalcanal. They did not possess the knowledge or the ability to logistically acquire the needed resources for massive reinforcement of the in-place units (16:22). Logistics problems such as these have been evident throughout history and have plagued even recent wars. Captain Andrew J. Ogan in his article "What About Logistics" said:

> In both Korea and Vietnam, the front-line forces faced the same resource movement difficulties encountered in World War II. While there were adequate stocks moving to the theater, insufficient port facilities and distribution

resources inhibited redistribution in the theater. (16:21)

The logistician plays a critical role in this strategy by identifying the requirements, obtaining the resources, and distributing them into the theater to the proper location. In order to deter and avoid the logistical precedents of the past, resupply concepts must provide for the rapid replenishment of our forces in future contingencies. Force sustainability will depend greatly on the logistics of rapid resupply.

Importance of Rapid Resupply

The importance of rapid resupply for present battles is an all encompassing factor in sustaining combat power. This importance becomes increasing highlighted, in lieu of the fact future wars will require a rapid, sustaining response with only those weapon systems in our possession at the time of war outbreak. Because of the "come-as-you-are" scenarios that are likely in the next war, there will not be time for traditional feedback systems such as military exercises to tell us what we should be doing or where the resources should be sent (14:2). As General James P. Mullins stated: "The entire war in the Falkland Islands required less time in execution than most exercises require in planning" (14:2). "Clearly, the old way of doing things just will not work" (14:2). Logistics support and movement control must be flexible to the situation at hand. General Mullins further stated:

> Ultimately, whatever system we do develop, must not only be totally interactive and dynamic, constantly distinguishing fact-of-life changes anywhere in the environment, but also it must employ some automatic mechanism to take corrective action in order to respond to those changes. (14:2)

"The failure to develop a sustainable, warfighting capability will guarantee a short war and, even worse, increase the probability of a nuclear confrontation" (21:4). It is therefore essential that our forces be sustained for an infinite period of time via a rapid resupply logistical lifeline (21:3).

Priority System

Methods of resupply used in the past have created many problems, one of which has been with movement control. As Major Gregory D. Stubbs pointed out in his article "Movement Control and Enhancing Contingency Resupply", "movement control involves the regulation of material flow based on total transportation capability and priority of multiservice need" (22:2). When the requirements exceed the transportation capability, decisions must be made about what goes first. These problems were evident during the Vietnam war when there was port congestion at both ends of the transportation systems and routine cargo of one service moved ahead of extremely urgent shipments of another. Major Stubbs also noted that at one point "125 cargo vessels awaited berthing at ports which could only accommodate 25-30 ships at a time" (22:3). The ships were usually unloaded in the order they arrived instead of unloading those ships with resources

that were needed first. Since no agency had an overall view of the state of the entire transport system and the shipments within it, the logistic support provided could not adjust to the combat operations being performed (22:2).

The Push System

Other resupply problems during the Vietnam War were caused by the type of resupply system that was used: the push system. The push system shipped material according to pre-planned consumption rates, not actual use (22:3).

> There was little or no supply discipline, resulting in duplicate requisitions, excessive quantities ordered, and abuse of movement priority systems. Finally, plans, programs, and combat operations changed rapidly, with little or no adjustment in supply.
>
> Since the total transportation system was saturated, an increase in resupply cargo flow simply was not possible, even if additional air and sealift assets had been available or port handling capability increased. This combination of a saturated transportation system, with neither additional lift resources nor port handling capability available, finally forced the issue. By late 1966, a theater-wide movement control system had been pieced together and was gearing up. (22:3)

As Captain Ogan and Lieutenant Colonel O'Neill noted in their article the push system "remains effective only when two logistics conditions are met: There must be an abundance of material and there must be ample time to acquire and move additional materials" (17:17). The push system was used in World War II, Korea, and Vietnam and as a result mountains of supplies were pushed into the theater. "Duplicate shipments were not uncommon and sometimes necessary to ensure that the combat forces received essential supplies" (17:17). But the

conditions that war will operate under in the future are differ vastly from those in the past.

> In the early months (or even years) of conflicts, the United States has always been able to mobilize troops far faster and more effectively than it has been able to arm them. The current era is no exception, but the consequences today may be far more significant for three reasons: a future war may be far shorter than previous ones; the development and production times for the sophisticated equipment of today are far longer; and the potential adversary...appears to be far more prepared. (9:109)

Over the past several years the number of contractors has been reduced due to the declining industrial base which in turn has reduced the availability of supplies and has even created a shortage of critical spares. Because of the declining industrial base and the reduction of contractors, there are no longer great quantities of assets available and the industrial base is not capable of rapidly producing them (17:17).

<u>Industrial Base Decline</u>

The decline in our industrial base, in recent years, has precipitated our inability to rapidly respond to accelerated production rates and surge capabilities.

> Our most recent experience, the Vietnam War, was perhaps not typical of future conflicts. We were fighting a greatly underequipped force in a war that built up very slowly, allowing ample time for industrial response. With the Congress authorizing greater funds than could be utilized, it still took the U.S. defense industry four years to increase production to the levels demanded by the military requirements. (9:109)

Additionally, during the Vietnam War no real test of the industrial base's surge capability existed.

> During the Vietnam War, the U.S. industrial base responded relatively smoothly to demands for war-fighting machinery and supplies. Aircraft, tracked vehicles, and munitions were produced in large quantities. However, because the United States generally set the pace of the military buildup in Southeast Asia, and since war materiel production was essential on a business-as-usual basis, the capability of the U.S. industrial base to accelerate or surge production to meet emergency requirements was largely untested. (25:9)

Reasons for the industrial base deterioration evolve around "declining productivity growth, aging facilities and machinery, shortages of critical materials, increasing lead times, and skilled labor shortages" (25:5). The declining productivity growth rate, measured by productivity improvements in the industrial base, can be traced to lack of capital investment (17:17). "Disincentives for investment in new facilities, equipment, and technology have resulted from a number of factors" (25:17).

> The decline in the procurement and research and development budget after the Vietnam conflict placed a serious burden on new investment in defense related work. Put simply, profits with the defense base generally did not sustain new investments. The problem was further compounded by abnormally high, and unanticipated, inflation during the 70's. This high inflation, coupled with high interest rates, further discouraged investment in new facilities and equipment. (25:17)

The use of exotic metals and scarce resources, linked with our dependence on other nations when acquiring these items, has created shortages and is central to the problem of long lead times.

> This dependence on foreign sources for raw materials vital to our industries has been increasing for many years. The United States is more than 50 percent dependent on foreign sources

for over half of the approximately 40 minerals which have been described as most essential to our...economy. (25:25)

Long lead times, effected by shortages of critical materials, are also a result of aging facilities and machinery, in that closure of forging and casting facilities and the lack of construction of new facilities created bottlenecks in production and manufacturing (25:13). Critical manpower shortages, a result of instability in the lower tiers of the defense industrial base, have been a contributor to increasing lead times and total costs (25:14). Overall, support in the industrial base has not kept pace with the demand for rapid resupply of military hardware, weapon systems, and spares.

Lack of material reserves and the reduced availability of supplies and spares can also be intertwined with the decline in our industrial base and limited funding over past years (17:19). In effect, limited funding led to a reduced number of spares being bought, which in turn reduced the number of suppliers, further creating a decline in the industrial base (17:19). Presently, the declined industrial base has lost its capability to rapidly provide supplies, equipment, and spares due to the economics of previous years (17:19). Even though there is a movement to "acquire increased stocks of spare parts and modern munitions, which will improve the readiness of existing forces" (18:41).

Airlift Capability

Because of the immediacy of wartime resupply, we can no

longer rely on sealift to fulfill all requirements, but instead rely heavily on airlift during the opening phases of a conflict. Without an abundance of assets and our reliance on airlift, "it is now necessary to correctly identify what stocks are required and where--and then to acquire and distribute those stocks, rather than to distribute before requirements are known those materials required to sustain forces" (17:17). Thus the element of time becomes a primary factor in future war considerations. The initial and latter stages of a limited war necessitate the use of rapid supply and resupply. "Where we once relied on sealift to fulfill all requirements, we are increasingly turning to airlift to meet our needs and anticipate airlifting stocks into the theater quickly" (17:19).

The movement of stocks by air, point toward another dilemma - restricted airlift capability. To counter this problem many enhancement programs have been established. "These programs include the C-141 stretch program, C-5A wing modification, C-5B and KC-10 acquisition, and continuing research and development of the C-17" (10:69). Although these programs will help reduce the problem of aircraft availability, it will not eliminate it (10:74).

Resupply Procedures

The current procedures for resupply start with the Joint Operation Planning System (JOPS) (13:15). This provides the means of translating national security objectives tasked in the Joint Strategic Capabilities Plan into workable military

plans to achieve those objectives (13:15). As Lieutenant Colonel Lawrence J. Faessler said in his article "JOPS and Resupply: The Connection", "The Joint Chiefs of Staff (JCS) sponsored JOPS is the primary tool used by a unified commander to create the current year operation plan for the defense of his area of responsibility" (8:2). The logisticians then create an automated expression of resupply transportation requirements (tons over distance) to compete for airlift and sealift in follow-on computer transportation feasibility simulation (8:2). The airlift schedules that are then created are to be used at the beginning of a conflict simply because of their existence and the lack of an alternative. Since the first days of any war will be critical, the movement of supplies must coincide with the scheduled deployment of units. If the tons over distance requirement can be reduced, then the movement of supplies can better coincide with the deployment of forces. This responsibility for coordinating the movement of supplies and the deployment of forces is the responsibility of the Joint Deployment Agency (8:2). The Joint Deployment Agency (JDA) is attempting to develop real resupply data for inclusion into the Transportation Operating Agencies movement schedule and also the unified commands Operation Plan (OPLAN). It should be noted, the Joint Chiefs of Staff have identified fundamental problems in planning procedures of JOPS and have directed the implementation of the Joint Operation Planning and Execution System (JOPES) (11:1).

> JOPES will support monitoring of readiness, and monitoring, planning, and execution of mobilization, deployment, employment, and sustainment activities both in peacetime and under crisis and wartime conditions. JOPES will cut across established organizational lines of responsibilities to achieve the close coordination among DOD and other federal sector components. (11:1)

JOPES will fully exploit state-of-the-art automated data processing (ADP) hardware and software and will coordinate the planning and execution of military operations (11:16). The JCS has scheduled a JOPES user group to be permanently located at JDA in Tampa, Florida by September 1984 (12:7).

The Air Force Logistics Command (AFLC) also provides a major contribution to resupply. As Dr. Raymond Pyles and Lt. Col. Robert S. Tripp stated, in their article "Measuring and Managing Readiness: An Old Problem- New Approach", the Air Force Logistics Command should strengthen its "ability to relate support decision to combat effectiveness" (19:18). This is a result of a general scarcity of resources when measured against requirements, and an increased awareness of the necessity to relate resources to readiness (23:35). Even though AFLC created the Logistics Operations Center, whose primary job is to shift assets to vital areas of need and to insure that available assets match actual requirements, there is still not an effective link between the battlefield commander and the responsiveness of the logistics system (5:50).

<u>Scenario for the Staging Base Concept</u>

The staging base concept can be utilized whenever a limited war has begun and the conflict is expected to last

more than sixty days. Fighter squadrons or wings will be deployed to an overseas location with WRSK and CFOSS kits deployed in support these forces. The location of the deployment may be a bare base with limited facilities and may be subject to enemy air strikes (21:12). The staging base concept could also be used at locations where U.S. forces are involved in situations that gradually escalate into conflicts requiring an increased U.S. commitment, i.e. the initial stages of the Vietnam War.

At some point within the first sixty days of a conflict, a decision would be necessary on whether or not to establish a staging base. Potential locations would then be subject to analysis with emphasis on pipeline lengths between CONUS and the staging base and the staging base and the FOB. The goal of this analysis would lead to a determination of the level of support or service the staging base would provide the FOB. If the analysis proves favorable and it becomes more advantageous for the FOB to order from a staging base than from the CONUS, the shipments of assets to the staging base would need to arrive prior to the sixty first day of the conflict.

Summary

It is evident that our forces, in order to sustain contingency operations, must be rapidly resupplied. The introduction of an in-theater staging base as an intermediary between the forward operating base and the CONUS may prove favorable in reducing the pipeline for replenishment, thereby

providing the means for rapid resupply.

Based on the historical precedents of the past and the problems encountered in the overall system, the usage of an in-theater staging base concept are of the upmost concern. We will enter a limited conflict with the spares, equipment, and supplies we presently possess, transporting them with any and all available aircraft under the specters of a declined industrial base and limited funding of previous years. In the final analysis, the need for faster response times in supporting field units is paramount. The in-theater staging base concept may provide the responsiveness required to sustain these units.

Under our present system the first sixty days of a war are supported with War Readiness Spares Kits (WRSK) and Combat Follow-On Spares Support (CFOSS) Kits (21:6). After sixty days the resupply of combat units is supported by normal peacetime stockage and resupply procedures (21:6). Because of our limited airlift capability, a majority of all sustaining supplies and spares will be transported by ship after the sixty day point. "The length of the pipeline can vary as much as 43 days between a CONUS and an overseas base and the variability can differ by as much as 19 days" (21:7-8). This hardly be termed reliable resupply for combat forces. Several studies conducted by the Air Force Logistics Management Center (AFLMC) have indicated that by shortening the pipeline, less stock may be required to provide better supply support (21:8). Since the concept of an in-theater

staging base would shorten the pipeline for support of our combat forces, this concept should result in better supply support for these forces.

III. Methodology

Chapter Overview

This chapter describes the methods used to develop answers for the research questions listed in Chapter I. Also described are the background for study, model assumptions, the structural model, model development, data extraction, data collection, verification and validation, and the methodology used in data analysis.

Research Questions

The research questions, as stated in Chapter I are:

1. If an in-theater staging base is established, are there any significant differences for an FOB ordering from the staging base compared to an FOB ordering from the CONUS in terms of order time, stock out time, number of orders and number of stock outs?

2. What is the sensitivity of the FOB operating with a staging base to changes in (1) the availability of lateral support, (2) the shipping time to the staging base, (3) the shipping time to the FOB, (4) the probability of interdiction at the FOB, and (5) changes in demand at the staging base?

Background

The current contingency resupply system has been deemed inadequate by HQ USAF because of its inflexibility and inefficiency in promoting and supporting the needs of the combat commander. This resupply system, demonstrating the qualities of both push and pull, was used during World War II for supply build-up prior to major offensives and used extensively throughout the war in Southeast Asia for

continuous resupply.

Even though limited usage of the current system, exhibiting the push concept, is presently applicable to the early stages of a contingency (prior to D+60), several alternatives for resupply after D+60 are available. Alternatives include the establishment of a depot in the theater, the construction of an in-theater Consolidated Intermediate Repair Facility (CIRF), employment of a resupply system similar to the European Distribution System (EDS), activation of a staging base designed to provide resupply support and maintenance repair support for forward operating bases (FOB), or any combination of two or more of these alternatives. Any or all of these alternatives may prove to be a better choice than the current resupply system if used during a contingency. There is very little supportive data on the subject of which system is better because the current resupply system has been used exclusively in limited warfare.

System Modeled

In our study, we chose to model the staging base resupply concept in lieu of the other alternatives and will demonstrate through simulation the improvements, if any, this system possesses over the continuous push/pull system currently in use. Improvements with the staging base resupply concept may occur in supply pipeline reduction, rapid replenishment, and reliability of supply support. The purpose of conducting this simulation will be to learn more about the behavior of the staging base resupply system and to

ascertain as much information about the system as possible without testing the actual system in use and thus incurring a much greater cost. The underlying premise of the concept for a staging base is that it acts as an intermediary between the FOB and CONUS capable of providing supply support. The models to be developed will be henceforth be known as the staging base model and the current resupply model. The staging base model will incorporate the use of the staging base concept. The current resupply model will not incorporate the use of the staging base concept but will emulate the current resupply system.

Model Assumptions

Staging Base Model Assumptions. The following assumptions for the staging base model apply:

1. The staging base and the CONUS sources of supply are not located within hostile territory and is, therefore, not subject to combat retaliatory strikes.

2. The conflict is a limited war and is, therefore, contained within one geographical location without direct confrontation between super powers or the use of nuclear weapons.

3. Conventional warfare is employed and no air superiority is assumed.

4. The staging base is operational prior to D+60 and upon activation at D+60 demand at the FOB has reached steady state.

5. Lateral support is available to fill orders at the FOB.

6. All replenishment orders required by the FOB are intermediated by the staging base. Orders from the CONUS are funneled through the staging base and forwarded to the FOB.

Current Resupply Model Assumptions. The following assumptions for the current resupply system model apply:

1. The CONUS sources of supply are not located within hostile territory and are not subject to attack.

2. The conflict is a limited war and is contained within one geographical location. There is no direct confrontation between super powers or the use of nuclear weapons.

3. Conventional warfare is employed and no air superiority is assumed.

4. Demand at the FOB is based on actual consumption rates compiled during D+60.

5. Lateral support is available.

6. Replenishment orders for the FOB are sent directly from the CONUS.

Structural Model

Basically, one model will be designed which will incorporate the staging base and FOB supply functions. From this model will be developed a representation of the FOB in operation without the staging base. Data will be gathered from simulation runs of both models and compared.

The objective of this simulation study is to determine the replenishment advantages, if any, the staging base concept possesses compared to that of the current resupply system. Response variables to be measured include the reorder time interval and stock out interval for the FOB based on predetermined factors while taking into account replenishment risks (supply line interdiction).

Input variables used to determine the responses for both the staging base and FOB include the (1) stock level, (2)

reorder quantity, (3) reorder point, (4) annual demand, (5) percent of supply line interdiction, (6) percent of lateral support, (7) annual customers, and (8) distance. These input variables result in a total of eight factors capable of variation between the FOB functions of both models. Additionally, only quantitative variables will be considered excluding those of qualitative value such as policies, organizations, geographical areas, and decision rules. Certain quantitative variables will be set and applied within USAF policy and regulation guidelines (i.e., variable values for cost to hold and cost to order).

Model Development

The model to be developed will simulate the actions that will occur at the staging base and the FOB. Initial stock levels will be determined for the FOB and the staging base for each item that is used in the simulation. The arrival of customers will be generated and the demand for items by each customer will be subtracted from the on-hand quantity. When the stock level reaches the reorder point, a stock replenishment action will take place that will represent the time delay necessary for the FOB or the staging base to receive its shipment. The quantity being ordered for stock replenishment will be equal to the EOQ of the items being ordered. The staging base will always receive its EOQ from the CONUS but the FOB may not receive its EOQ if the staging base has a quantity less than the FOB EOQ. In this case, the staging base will ship the quantity that is on hand and the

remaining items that would make up the FOB EOQ will either come from lateral support or be placed in backorder at the staging base. This is done because it is assumed that the FOB would have priority over the staging base for the remaining items on the shelf at the staging base. All shipments arriving at the FOB will be considered for destruction upon arrival based on the percentage of interdiction that is expected.

The staging base model will be developed to simulate all of the above actions. From this model the staging base actions will be extracted and the result will provide the current resupply model in which all FOB stock replenishment actions will go directly to the CONUS. The current resupply model, operating without the staging base, will perform many of the same actions as described above. The arrival of customers will be generated and the demand by each customer will be subtracted from the on-hand stock level. When the reorder point is reached, the FOB will order its EOQ from the CONUS after first checking to see if lateral support is available. In this program the shipping time from CONUS to the FOB will be the same as the shipping time to the staging base in the previous model. This is done to form a basis for later comparisons of data between the two models. If we were to assume that the shipping time from the CONUS to the FOB was the same as the shipping time from the CONUS to the staging base plus shipping time from the staging base to the FOB, it would be natural to assume that the FOB would be out

of stock longer without the staging base and any comparisons of data would be invalid. The time it takes the FOB to receive lateral support will be the same time as in the model with the staging base. Also, the percentage of times that supplies are destroyed upon arrival at the FOB will be the same as on the previous model. One difference in the current resupply model is that partial shipments are not made from the CONUS or through lateral support. Only the EOQ quantity is shipped.

Data Extraction

The functional aspect of the models is developed on the basis of what can be accomplished in the simulation and the experimental aspect of the models is concerned with how the results of the simulation will be produced. The method used to extract data from the models will consist of varying one factor at a time while keeping all others constant (17:163). This procedure will be duplicated until each factor has been explored while the other remain unchanged (17:163). Additionally, the eventual varying of all factors will determine the sensitivity of the model and the degree to which these factors effect the response variables of the models.

Quantity Calculations

A modified version of the Wilson EOQ formula will be used to determine the EOQ quantities throughout the simulation. The formula contains a computed factor for the

cost to hold and the cost to order. Additionally, this formula is used exclusively in developing EOQ quantities for items in the Air Force inventory that are considered economic order quantity items (7:p 11-13). At one time, the Air Force supply system used a derivation of this formula which included computing a variable stockage objective (VSO), but has since dispensed with that calculation in lieu of the modified Wilson EOQ formula. All EOQ formulas were extracted from AFM 67-1, Volume II, Part Two, Chapter 11, page 11-13 for use in computing EOQ related quantities and will be shown in the following section.

Data Collection

The data to be used in the program will be obtained from an Air Force Logistics Management Center (AFLMC) study (4:12). These items are reproduced in Table I. The sample items used in the simulation "had both high and low order frequency, demand totals, costs, and variances" (4:3). The items display as "many different demand characteristics as are found in a real-life setting" (4:3). The unit cost, yearly customers, and annual units demanded from this study were duplicated and used in a computer input file. This input file is used because the staging base model has the capability of calculating the order and shipping time quantity (O&STQ), the safety stock, and the order and shipping time (O&ST) for the staging base. The model can perform these calculations based on the actual time that it takes Upper Heyford RAF, England to obtain supplies from each

TABLE I

Data Sample

Item	Unit Cost	Annual Units Demanded	Annual Customers
1	4.71	626	83
2	2.19	521	5
3	27.02	1	1
4	2.34	321	15
5	.33	173	20
6	.20	27	5
7	.53	94	16
8	42.69	234	15
9	15.00	4	4
10	2.60	7	4
11	19.80	3	3
12	2.25	69	37
13	3.50	160	78
14	.67	143	11
15	.92	148	32
16	.95	2	1
17	.60	1	1
18	.44	1	1
19	2.58	35	22
20	.39	26	5
21	.10	3	3
22	.69	2	1
23	2.20	306	34
24	.35	41	10
25	2.85	245	22
26	.11	29	8
27	81.20	1	1
28	1.83	8	4
29	28.10	126	54
30	.90	631	122
31	.73	1853	47
32	.55	95	18
33	41.50	4	2
34	2.40	89	23
35	1.44	1827	158
36	1.56	1946	159
37	7.60	42	14
38	1.15	35	8
39	24.71	3	3
40	3.38	23	9

source of supply identified in an AFLMC order and shipping time study (2:25). The same data will be used in current resupply model to calculate the O&STQ, O&ST, and safety stock. Each item will be assigned the same routing identifier (RI) code and the same Expendability, Recoverability, and Repairability Code (ERRC) for ease of sensitivity analysis. Since the mean out of stock time, reorder time, number of orders, and number of times out of stock will be aggregated for all forty items, all items will be assigned to routing identifier "FFZ". The mean lead time away and standard deviation for "FFZ" will be manually changed prior to the simulation runs.

Means of 60, 30, and 15 days and standard deviations of 20, 20, and 10 days respectively will be used. The mean of 60 and standard deviation of 20 will be used because they were representative of several of the different sources of supply in the AFLMC order and ship time study for peacetime routine orders. Additionally, the mean of 60 represents one extreme order and ship time and the long pipeline that would result from using ships for transporting supplies for force sustainment after the first sixty days of a limited war.

The mean of thirty and standard deviation of 15 will be used to represent the faster resupply times that may result from high priority shipments associated with the limited availability of cargo aircraft or the fact the staging base location is closer to the CONUS.

The mean of 15 and standard deviation of 10 will be used

to represent the resupply pipeline in the event the staging base is located even closer to the CONUS or in the event that the availability of cargo aircraft allows for and even faster resupply time. The purpose of varying the lead time away in the staging base model and the current resupply system is to determine the effect that the lead time away has on the stock out time, number of stock outs, reorder time and number of reorders.

Upon reading the input file, both models will calculate daily customer arrival rate, lot size, the EOQ, the O&STQ, the safety stock, the reorder point, and the initial stock level. These equations are shown below:

$$\text{Customer arrival Rate} = \frac{\text{Yearly customers}}{365} \tag{1}$$

$$\text{Lot size} = \frac{\text{Yearly Units}}{\text{Yearly Customers}} \tag{2}$$

$$\text{O\&STQ} = \frac{\text{Year Units}}{365} \tag{3}$$

$$\text{Safety Stock} = \frac{3 \times \text{Yearly Units} \times \text{O\&STQ}}{365} \tag{4}$$

$$\text{Reorder Point} = \text{O\&STQ} + \text{Safety Stock} \tag{5}$$

$$\text{EOQ} = 5.9 \sqrt{\frac{\text{Annual Units} \times \text{Unit Cost}}{\text{Unit Cost}}} \tag{6}$$

The program will generate a different exponential time between the arrival of customers at both the staging base and the FOB. Each customer will order the same lot size at both the staging base and the FOB. Sensitivity will be done later at the staging base to determine what effect if any changes

in the arrival rate of customers at the staging base has on the variables being measured at the FOB.

All shipping times will be generated by a log normal distribution. Shipping time to the FOB from lateral support and the staging base will be generated using the same mean and standard deviation in the staging base model.

The availability of lateral support and interdiction is determined by selecting a random number and checking to see if it is within the percentage of time that lateral support or interdiction would be available. Because interdiction is not determined until the shipment has arrived at the FOB, it has the effect of presenting the "worst" case for the FOB. If the shipments were destroyed at a much earlier point, the FOB would be able to start a stock replenishment action and would, in effect, be able to reduce its out of stock time.

The staging base model will examine the reorder point at the staging base daily and will initiate a stock replenishment action if the quantity on hand plus any quantity being shipped to the staging base is less than the reorder point. The model will also examine the reorder point daily at the FOB and initiate a stock replenishment if the quantity on hand, plus (1) any quantity being shipped from the staging base, plus (2) any quantity on back-order at the staging base for the FOB, plus (3) any quantity being shipped from lateral support, is less than the reorder point for that item.

When the staging base receives a shipment, it will

adjust its stock level accordingly and then check to see if the FOB has any backorders for that item. If backorders are present, the staging base will fill as many as possible with its available stock. This is done because there can be more than one backorder created by the FOB while the staging base was out of stock. When the backorders are filled they will be treated the same as other shipments to the FOB as far as shipping time and interdiction are concerned.

Verification and Validation

Verification of the model will be done by placing statements throughout the staging base program and the current resupply program to verify that, the programs perform the functions discussed under Model Development. The "print" statements will print out information of daily occurrences of events. The following are examples of these statements:

1. The information read from the input file.
2. All of the quantities that were calculated (EOQ, safety stock, beginning stock level, reorder point, etc.).
3. The day on which demand occurred.
4. The quantity demanded.
5. The new stock level after daily demand has been subtracted.
6. The activation of a stock replenishment action and the quantity on the shelf or in the pipeline when the stock replenishment action begins.
7. The source of resupply for the FOB.
8. The quantity being shipped to the FOB or staging base.

9. The destruction of supplies upon arrival at the FOB.

This information will then be used to verify that the statistics printed out are correct. For example, the number of times that the FOB is out of stock will be manually calculated during the year based on the printed information, and verified against the statistic that is printed out at the end of the year. This will be done for each statistic shown at the end of a simulation run to verify that statistic.

The validation of each simulation model will be considered during model development. A simulation model of a complex system should not be described in terms of absolute validity or invalidity, but should address the degree to which the model agrees with the actual system. The final validation of each simulation program will be done by the sponsor of this thesis, the AFLMC, to insure that it is representative of the current resupply system, and of the proposed staging base resupply system.

<u>Model Simulation</u>

After the shipping times, percentage of lateral support, and percentage of interdiction are equally set in both the staging base model and the current resupply model, the simulation of each model will begin. Each program will calculate the necessary equations, stock levels, customers, and demands for the item. Only one item will be simulated at a time and the simulation will last for one year. Statistics will be kept during that year on the time out of stock,

number of stock outs, reorder time, and number of orders. These figures will be averaged at the end of the year and retained by the program. Thirty simulations will be done on each item since each simulation only represents one data point for that item. Thirty simulations are necessary to overcome the differences of the random number seeds that we used during the simulation. Since the seeds are not reset after each simulation, the data point obtained by the next simulation is characteristic of the stream numbers generated during that simulation. Statistics of the thirty simulations will be averaged together to obtain one statistic for each variable being measured. The program will then reset all of the totals of the variables being measured, read the necessary data for the next item, and begin the simulation again. Each of the forty items will be simulated thirty times and the final statistics will be printed out for each item.

Method of Analysis

This section describes the method for data analysis for the two research questions. Each question is stated and then data analysis procedures are described.

Research Question 1. What major effect does the staging base have on the support effectiveness for the FOB? A lengthy process involving numerous simulation runs will provide the answer to this question. Results from both simulation runs will be compared using hypothesis testing and the Statistical Package for the Social Sciences (SPSS)

subprogram for variance analysis known as the Anova Test. The hypothesis test in conjunction with the Anova Test will analyze mean differences between the response variables of both models. Testing will reveal any significant differences in the variation of the means in the response variables. Collectively analyzed, the above methodology will provide insight into the effect the staging base has on support effectiveness for the FOB.

<u>Research Question 2</u>. What is the sensitivity of the staging base system to changes and variations in the overall supply system? Information to answer this question will be derived primarily from varying one input variable at a time while keeping the others constant. Variables will be explored on a spectrum ranging from one extreme to another. Output responses will then be compared using the methodology explained for research question one. Testing will reveal any significant differences in the response variables of the models.

<u>Summary</u>

This chapter provided an explanation of the methodology used to develop answers for the research questions. The actual analysis of the data is reported in the following chapter on research findings.

IV. Analysis of Results

Overview

This chapter analyzes the results on successive simulation runs on both the staging base model and current resupply model. The results from both models are analyzed and compared against each other under similar conditions. Further analysis of the staging base model tested additional input variables and provided another basis for comparison. Also in this chapter, model verification will be discussed followed by the results pertaining to the response variables and research questions. Finally, the chapter will conclude with a summary of the major findings.

Response Variable Findings

The F statistic was used to analyze the characteristics of each model. In every case, after using the same input variables, the performance of one model was compared with the performance of the other model. In each case, the null hypothesis was that there was no significant difference between the two systems. The alternate hypothesis was that there was a significant difference in the two systems. Using these hypotheses, the models were compared and a calculated F statistic obtained. The calculated F statistic was then compared to the standard table F statistic value at a 95% confidence interval. A significant difference between the systems ensued if the calculated F statistic exceeded the standard table value.

Reorder Time

Reorder time was a function of distance measured in both models by the time it took the FOB to receive items from the CONUS (current resupply model) versus the time required to receive items from the staging base (staging base model). The calculation of reorder times began with need identification and ended upon receipt of the property. In every instance, analysis of the reorder time proved to be significant. That is, the calculated F statistic was comparatively higher than the standard table value, indicating a significant difference in the two systems.

The reorder times were the products of a log normal distribution with varying means and standard deviations which provided a way to access the sensitivity of the models. It is assumed in all cases that the distance from the CONUS to the staging base/FOB is always larger than the distance from the staging base to FOB. By varying the shipping time from the CONUS to the staging base (staging base model) and the FOB (current resupply model) while holding all other variables constant for a series of simulation runs, analysis of the reorder times revealed the staging base model achieved better results than the current resupply model. This point is illustrated in TABLE II by simulation numbers 1, 2, 4, 5, and 6. Simulation number 3 of Table II reveals the mean reorder time for the current resupply model is smaller than that of the staging base system. This simulation assumed the distance (shipping time) from the CONUS to the staging

TABLE II

Mean Reorder Times

Number	Model	Order and Shipping Times CONUS to SB/FOB	Order and Shipping Times SB to FOB	Mean Reorder Time
1	Staging Base	60 days	20 days	15.68 days
	Current Resupply	60 "	---	47.66 "
2	Staging Base	30 days	20 days	15.80 days
	Current Resupply	30 "	---	22.64 "
3	Staging Base	15 days	20 days	16.27 days
	Current Resupply	15 "	---	12.08 "
4	Staging Base	60 days	10 days	7.87 days
	Current Resupply	60 "	---	47.66 "
5	Staging Base	30 days	10 days	7.87 days
	Current Resupply	30 "	---	22.64 "
6	Staging Base	15 days	10 days	7.85 days
	Current Resupply	15 "	---	12.08 "

base/FOB was shorter than the distance from the staging base to the FOB.

The following findings resulted from the study of the reorder times. The staging base concept provides for a shorter reorder time interval than the current resupply system. When the distance from the CONUS to the staging base/FOB is shorter than the distance from the staging base to the FOB, the current resupply model produces better results than the staging base model.

Out of Stock Time

Out of stock time was measured from the point the stock level at the FOB reached a zero balance until stock replenishment placed it above the zero balance. The out of stock time, like the reorder time, was a function of distance. Analysis indicated the further the FOB was from its source of supply the greater the stock out time interval. When the order and shipping time from the CONUS to the staging base/FOB was greater than the order and shipping time from the staging base to the FOB, the staging base model continuously achieved better results than the current resupply model. The mean out of stock times for the staging base model were consistently lower than those of the current resupply model (reference simulation numbers 1-9 of Table III). In each of these cases compared, the calculated F statistic was always higher than the standard table value indicating a significant difference in the two systems modeled. It should be noted that these simulations did not

TABLE III

Mean Out of Stock Times

Number	Model	Order and Shipping Times CONUS to SB/FOB	Order and Shipping Times SB to FOB	SB Annual Demand	Mean Stockout Time
1	Staging Base	60 days	20 days	1/2 FOB	10.03 days
	Current Resupply	60 "	---	---	19.03 "
2	Staging Base	30 days	20 days	1/2 FOB	10.40 days
	Current Resupply	30 "	---	---	15.66 "
3	Staging Base	60 days	20 days	Equal	10.44 days
	Current Resupply	60 "	---	---	19.03 "
4	Staging Base	30 days	20 days	Equal	9.97 days
	Current Resupply	30 "	---	---	15.66 "
5	Staging Base	60 days	20 days	2 x FOB	11.24 days
	Current Resupply	60 "	---	---	19.03 "
6	Staging Base	30 days	20 days	2 x FOB	10.74 days
	Current Resupply	30 "	---	---	15.66 "
7	Staging Base	60 days	10 days	Equal	6.52 days
	Current Resupply	60 "	---	---	19.03 "
8	Staging Base	30 days	10 days	Equal	6.32 days
	Current Resupply	30 "	---	---	15.66 "
9	Staging Base	15 days	10 days	Equal	5.85 days
	Current Resupply	15 "	---	---	8.67 "
10	Staging Base	15 days	20 days	1/2 FOB	9.56 days
	Current Resupply	15 "	---	---	8.67 "
11	Staging Base	15 days	20 days	Equal	9.11 days
	Current Resupply	15 "	---	---	8.67 "
12	Staging Base	15 days	20 days	2 x FOB	9.96 days
	Current Resupply	15 "	---	---	8.67 "

allow for lateral support or supply line interdiction. Both of these items will be discussed in later sections.

Further sensitivity analysis was done testing the assumption that the distance from CONUS to the staging base/FOB was shorter than the distance from the staging base to the FOB. The F statistical data in these cases revealed no significant difference in the two systems. Mean out of stock data in Table III for simulations 10 through 12 showed the current resupply model had slightly lower out of stock times than the staging base model.

The following findings resulted from the study of the out of stock times when no lateral support or supply line interdiction were evident. The staging base concept provides for a shorter stock out time interval than the current resupply system. When the distance from the CONUS to the staging base/FOB is shorter than the distance from the staging base to the FOB, the current resupply model produces better results than the staging base model.

Number of Reorders

The number of reorders was a function of the number of times the FOB reached the reorder point and requested additional items in anticipation of future needs. In every case analyzed, regardless of stockage policy, lateral support, supply line interdiction, or distance the FOB was from its source of supply, the two systems performed on an equal basis. At no time, did the F statistic of any comparison prove to be significant. The mean number of

reorders for both systems were consistently close, if not equal, to each other as indicated by Table IV.

The following finding resulted from the study of the number of reorders. Both systems, the staging base system and the current resupply system, generate a similar number of reorders during the replenishment cycle.

Number of Stock Outs

The number of stock outs was a function of the number of times the FOB stock level reached a zero balance while awaiting replenishment. In each simulation, regardless of the stockage policy, lateral support, supply line interdiction, or distance the FOB was from the source of supply, the two systems performed on a nearly equal basis. The F statistic did not prove to be significant in any of the simulations analyzed. The mean number of stock outs for both systems was nearly equal in every case as shown in Table V.

The following finding resulted from studying of the number of stock outs. Both models experience a similar number of stock outs during the replenishment cycle.

Performance with Lateral Support

Simulations were performed with lateral support being available to FOB none of the time, 10% of the time, and 20% of the time. These percentage rates showed no significant effect on the output variables. As illustrated by Table VI, neither the reorder time, stock out time, number of reorders, nor number of stock outs showed any significant improvements in either model.

TABLE IV

Mean Number of Reorders
(In Days)

Number	Model*	Order and Shipping Times CONUS to SB/FOB	SB to FOB	SB Annual Demand	Percentage of Interdiction/ Lateral Support	Annual Mean Number of Reorders
1	SB	60	20	1/2 FOB	.00/.00	2.56
	CR	60	----	---	.00/.00	2.70
2	SB	30	20	1/2 FOB	.00/.00	2.56
	CR	30	----	---	.00/.00	2.60
3	SB	15	20	1/2 FOB	.00/.00	2.56
	CR	15	----	---	.00/.00	2.53
4	SB	30	20	Equal	.00/.00	2.56
	CR	30	----	---	.00/.00	2.60
5	SB	30	20	2 x FOB	.00/.00	2.56
	CR	30	----	---	.00/.00	2.60
6	SB	60	20	Equal	.00/.10	2.56
	CR	60	----	---	.00/.10	2.70
7	SB	30	20	Equal	.00/.20	2.57
	CR	30	----	---	.00/.20	2.60
8	SB	15	20	Equal	.00/.20	2.57
	CR	15	----	---	.00/.20	2.53
9	SB	60	20	Equal	.10/.00	2.83
	CR	60	----	---	.10/.00	3.00
10	SB	30	20	Equal	.20/.00	3.17
	CR	30	----	---	.20/.00	3.20
11	SB	60	20	Equal	.20/.20	3.19
	CR	60	----	---	.20/.20	3.26
12	SB	30	20	Equal	.20/.20	3.18
	CR	30	----	---	.20/.20	3.19

* Under the Model column, SB denotes the staging base model and CR denotes the current resupply model.

TABLE V

Mean Number of Stockouts
(In Days)

Number	Model*	Order and Shipping Times CONUS to SB/FOB	Order and Shipping Times SB to FOB	SB Annual Demand	Percentage of Interdiction/ Lateral Support	Annual Mean Number of Stk Outs
1	SB	60	20	1/2 FOB	.00/.00	0.755
	CR	60	----	---	.00/.00	0.479
2	SB	30	20	1/2 FOB	.00/.00	0.753
	CR	30	----	---	.00/.00	0.708
3	SB	15	20	1/2 FOB	.00/.00	0.722
	CR	15	----	---	.00/.00	0.794
4	SB	30	20	Equal	.00/.00	0.728
	CR	30	----	---	.00/.00	0.708
5	SB	30	20	2 x FOB	.00/.00	0.720
	CR	30	----	---	.00/.00	0.708
6	SB	60	20	Equal	.00/.10	0.726
	CR	60	----	---	.00/.10	0.468
7	SB	30	20	Equal	.00/.20	0.712
	CR	30	----	---	.00/.20	0.632
8	SB	15	20	Equal	.00/.20	0.709
	CR	15	----	---	.00/.20	0.816
9	SB	60	20	Equal	.10/.00	0.836
	CR	60	----	---	.10/.00	0.639
10	SB	30	20	Equal	.20/.00	0.942
	CR	30	----	---	.20/.00	0.844
11	SB	60	20	Equal	.20/.20	0.909
	CR	60	----	---	.20/.20	0.610
12	SB	30	20	Equal	.20/.20	0.909
	CR	30	----	---	.20/.20	0.759

* Under the Model column, SB denotes the staging base model and CR denotes the current resupply model.

TABLE VI

Model Performance with Lateral Support
(In Days)

Model*	Percentage of Interdiction/ Lateral Support	Order and Shipping Time from CONUS**	Mean Reorder Time	Mean Stockout Time	Annual Mean Number of Reorders	Annual Mean Number of Stk Outs
SB	.00/.00	60	15.68	10.44	2.56	0.753
SB	.00/.10	60	15.88	10.62	2.56	0.726
SB	.00/.20	60	15.44	10.56	2.56	0.716
SB	.20/.20	60	15.48	16.85	3.19	0.909
CR	.00/.00	60	47.66	19.03	2.70	0.479
CR	.00/.10	60	46.69	18.04	2.70	0.467
CR	.00/.20	60	48.00	16.84	2.70	0.433
CR	.20/.20	60	46.97	24.94	3.26	0.610
SB	.00/.00	30	15.80	9.97	2.56	0.728
SB	.00/.10	30	15.66	9.80	2.56	0.674
SB	.00/.20	30	16.06	10.37	2.57	0.712
SB	.20/.20	30	16.02	14.88	3.18	0.909
CR	.00/.00	30	22.64	15.66	2.60	0.708
CR	.00/.10	30	22.45	15.07	2.60	0.804
CR	.00/.20	30	22.89	13.85	2.60	0.632
CR	.20/.20	30	22.96	17.37	3.19	0.759

* Under the Model column, SB denotes the staging base model and CR denotes the current resupply model.

** Shipping time from the staging base to the FOB is 20 days.

Studying the availability of lateral support at 10% and 20% level revealed that it had no significant effect on the reorder time, out of stock time, number of reorders, and number of stock outs for either system.

Performance with Supply Line Interdiction

The destruction of items destined for the FOB was tested at three levels. Shipments were subject to supply line interdiction none of the time, 10% of the time, and 20% of the time. Although no significant differences occurred in the reorder time, number of reorders, and number of stock outs, an increase in the out of stock time for both models was apparent as illustrated by Table VII. As the percentage of interdiction increased, the mean out of stock times of both models concurrently increased.

A following findings resulted from the study of supply line interdiction of shipments to the FOB. The out of stock time increased as the level of interdiction increased. The reorder time, number of reorders, and number of stock outs were not significantly effected.

Staging Base Annual Demand

The annual demand for the staging base was set at three different quantities to determine if a degradation in supply support to the FOB would occur. The levels for the staging base were set at one half the FOB level, equal to the FOB level, and twice the FOB level. At no time did supply

TABLE VII

Model Performance with Supply Line Interdiction
(In Days)

Model*	Percentage of Interdiction/ Lateral Support	Order and Shipping Time from CONUS**	Mean Reorder Time	Mean Stockout Time	Annual Mean Number of Reorders	Annual Mean Number of Stk Outs
SB	.00/.00	60	15.68	10.44	2.56	0.753
SB	.10/.00	60	15.07	14.11	2.83	0.836
SB	.20/.00	60	16.05	16.54	3.13	0.945
SB	.20/.20	60	15.48	16.85	3.19	0.909
CR	.00/.00	60	47.66	19.03	2.70	0.479
CR	.10/.00	60	47.24	20.07	2.95	0.639
CR	.20/.00	60	46.70	29.51	3.26	0.733
CR	.20/.20	60	46.97	24.94	3.26	0.610
SB	.00/.00	30	15.80	9.97	2.56	0.728
SB	.10/.00	30	15.74	12.37	2.84	0.823
SB	.20/.00	30	15.96	14.73	3.17	0.942
SB	.20/.20	30	16.02	14.88	3.18	0.909
CR	.00/.00	30	22.64	15.66	2.60	0.708
CR	.10/.00	30	22.36	16.94	2.87	0.755
CR	.20/.00	30	22.70	18.92	3.20	0.844
CR	.20/.20	30	22.96	17.37	3.19	0.759

* Under the Model column, SB denotes the staging base model and CR denotes the current resupply model.

** Shipping time from the staging base to the FOB is 20 days.

support from the staging base to the FOB show any tendencies of support degradation. The F statistic indicated no significant difference in the out of stock times at the FOB for any of the annual demand levels at the staging base and the mean out of stock times were comparatively similar.

The following finding resulted from analyzing the effect of different annual demand levels at the staging base. There is no degradation in the support effectiveness at the FOB with variations in annual demand by the staging base.

Actual Verification

The statistics gathered on each model have been verified as being accurate. This was done by manually counting the occurrences of each individual statistic for one year from the complete print out of each event. The appropriate total or mean of the variable was then checked against the year end statistic to ensure accuracy. This was also done for a second simulation year to ensure that the accumulated statistics were an average of the ones gathered at the end of both the first and second simulations. After these were verified as accurate, we concluded that the statistics collected at the end of thirty simulation runs would be an average of each statistic as it occurred during each of the thirty simulations. The process was then repeated with the second item used in the simulation to ensure that all of the appropriate variables or totals were reset to zero before the simulation began. These statistics were also verified as accurate. It was concluded the statistics accumulated at the

end of thirty simulations were an average of all occurrences and applied only to the item being simulated. Upon completion of this process all of the print statements were taken out of the program and only the statistics at the end of thirty simulations were printed for each item.

Summary of Major Findings

A summary of the major findings, which effectually answer the research questions, are presented below.

1. The staging base model provides for a shorter reorder time interval than the current resupply model.

2. The staging base model provides for a shorter out of stock time interval than the current resupply model.

3. The staging base model and the current resupply model generate a similar number of reorders during the replenishment cycle.

4. The staging base model and the current resupply model experience a similar number of stock outs during the replenishment cycle.

5. When the distance from the CONUS to the staging base/FOB is shorter than the distance from the staging base to the FOB, the current resupply model provides better supply support than the staging base model.

6. The availability of lateral support at a 10% and 20% level had no real effect on the reorder time, the out of stock time, number of reorders, and the number of stock outs for either system.

7. The presence of supply line interdiction of 10% and 20% revealed the out of stock time increased as the level of interdiction was increased. No significant effect was registered on the reorder time, number of reorders, and number of stock outs.

8. Varying the annual demand at the staging base had no degradation in the supply support for the FOB.

Summary

This chapter provided an analysis of the results relating to the output variables and summarized the major findings. The following chapter will draw conclusions from this thesis effort and make recommendations for further study.

V. Conclusions and Recommendations

Overview

This chapter will first review the significant issue of this research effort and the formulate conclusions drawn from the analysis of the staging base concept. Suggestions for further research will follow and will accent areas capable of providing an expansion of this study.

Main Issue

The main issue of this thesis effort centered about supply effectiveness for an FOB with the establishment of in-theater staging base as an intermediate source of supply. The literature review, simulation model development, and analysis of the results of the simulation, all focused on this main issue. The literature review provided background for the study and revealed past and present methods of resupply. Model development used the ideas expounded upon in the literature review and transformed them into tangible simulation models capable of partially emulating the staging base concept and current resupply system. Finally, analyzing the results of the simulations provided a basis for formulating conclusions addressed in the next section.

Conclusions

The conclusions alluded to in this section are based on the analysis of the statistics generated by multiple simulations in comparing the staging base system with the current resupply system.

1. The staging base system provides better overall supply support for an FOB than the current resupply system.

2. The aggregate stock out time and stock replenishment time for an FOB is significantly lower when the FOB orders from a staging base than when ordering from the CONUS.

3. There is no significant difference in the numbers of orders initiated or number of times out of stock for an FOB operating with or without a staging base. It must be emphasized, in order to be effective, the shipping time from the staging base to the FOB must be less than the shipping time from the CONUS to the FOB.

4. A staging base should not be established as a supply intermediary if the shipping time from the staging base to the FOB is greater than the shipping time from the CONUS to the FOB.

5. With the staging base concept already in place, lateral support, as simulated in this thesis, had no significant effect on the reorder time, out of stock time, number of orders, and number of stock outs at the FOB.

6. Supply line interdiction, under the staging base concept, does not significantly effect the reorder time, number of reorders, and number stock outs at an FOB. However, the out of stock out time will increase significantly.

7. The annual demand level at the staging base for items also used at the FOB will not interfere will the support effectiveness provided to the FOB by the staging base.

8. This simulation of the staging base concept was successful in effectively supporting an FOB using a 40 item sample. This concept should be equally successful in simulation with a much larger data sample.

9. Because of the success of the staging base system in simulation with EOQ items, this system should be just as effective in providing support for reparable items. This conclusion is based on the idea that a much shorter pipeline would be in use with a staging base.

Recommendations for Further Study

Further research of the staging base concept should include studying the effects the concept has on reparable items. Although it was concluded that this concept should work for reparable items, a study would verify the conclusion. A greater quantity of items should be tested. In other words, further research should simulate beyond the 40 item sample developed in this thesis. Finally, a study should be conducted to compare the staging base system with other alternative resupply systems.

Final Note

It is apparent that our forces, in order to sustain operations must be rapidly resupplied. The introduction of an in-theater staging base as an intermediary between an FOB and the CONUS has proven favorable, during simulation, in reducing the pipeline for replenishment and thereby providing the means for rapid resupply. The need for faster response times in supporting field units is of the upmost concern. The actual use of the in-theater staging base concept may provide the responsiveness required to sustain these units.

Appendix A: Simulation Program of the Staging Base Model

```
PREAMBLE  ''BEGIN

EVENT NOTICES INCLUDE DAY.BEGIN   ''STAGING BASE CONCEPT BEGINS

PROCESSES INCLUDE
          FORWARD.OPERATING.BASE, ''FORWARD OPERATING BASE
          FOB.RESTOCK,            ''FORWARD OPERATING BASE RESTOCK
          CHECK.STK.OUT,          ''CHECK STOCK OUT AT FOB
          SB.CHECK.STK.OUT,       ''CHECK STOCK OUT AT
                                  ''STAGING BASE
          SB.RESTOCK,             ''STAGING BASE RESTOCK
          STAGING.BASE,           ''STAGING BASE
          SUPPLIES.DESTROYED,     ''SUPPLIES DESTROYED AT FOB
          EOQ,                    ''ECONOMIC ORDER QUANTITY
          SB.DEMAND,              ''STAGING BASE DEMAND
          FOB.DEMAND,             ''FOB DEMAND
          BO.DESTROYED,           ''BACKORDERS DESTROYED
          BO.ADDED.FOB,           ''BACKORDERS ADDED AT FOB
          LATERAL.CHECK,          ''LATERAL SUPPORT CHECK
          STATS                   ''STATISTICS


          EVERY FOB.RESTOCK HAS A N1
          EVERY LATERAL.CHECK HAS A B1
          EVERY SUPPLIES.DESTROYED HAS A D1
          EVERY SB.RESTOCK HAS A E1
          EVERY FORWARD.OPERATING.BASE HAS A J1
          EVERY STAGING.BASE HAS A G1


DEFINE FOB.STK.LV,           ''FOB STOCK LEVEL
       FOB.EOQ,              ''FOB ECONOMIC ORDER QUANTITY
       FOB.RE.PT,            ''REORDER POINT FOR AN ITEM AT THE FOB
       F.AD,                 ''ANNUAL DEMAND FOR AN ITEM AT THE FOB
       FOB.SFTY.STK,         ''AMOUNT OF SAFETY STOCK FOR AN ITEM
                             ''AT THE FOB
       FOB.OSTQ,             ''THE QUANTITY OF A ITEM IN THE
                             ''PIPELINE FOR THE FOB
       SB.STK.LV,            ''STAGING BASE STOCK LEVEL
       SB.EOQ,               ''STAGING BASE ECONOMIC ORDER QUANTITY
       SB.RE.PT,             ''REORDER POINT FOR AN ITEM AT THE
                             ''STAGING BASE
       SB.AD,                ''ANNUAL DEMAND FOR AN ITEM AT THE STAGING
                             ''BASE
       SB.SFTY.STK,          ''AMOUNT OF SAFETY STOCK FOR AN ITEM AT
                             ''THE STAGING BASE
       SB.OSTQ,              ''THE QUANTITY OF A ITEM IN THE
                             ''PIPELINE FOR THE STAGING BASE
       TEST.1,               ''TRUE OR FALSE CONDITION
```

```
        TEST.2,                 ''TRUE OR FALSE CONDITION
        1.STK.LV.TEST,          ''TRUE OR FALSE CONDITION USED
                                ''WHEN THE STOCK LEVEL AT THE FOB
                                ''IS <= ZERO
        2.STK.LV.TEST,          ''TRUE OR FALSE CONDITION USED
                                ''WHEN THE STOCK LEVEL AT THE SB
                                ''IS <= ZERO
        REPS,                   ''CURRENT NUMBER OF REPETITIONS
        NO.FOB.BO,              ''COUNTS THE NUMBER OF TIMES THE
                                ''FOB HAS A BACKORDER
        DA.PT,                  ''THE TOTAL NUMBER OF DATA POINTS
                                ''THAT ARE SIMULATED FOR ONE ITEM
        SUP.DESTROYED,          ''THE TOTAL NUMBER OF SHIPMENTS THAT
                                ''ARE DESTROYED IN ROUTE TO THE FOB
        SUP.LAT,                ''A COUNTER FOR THE NUMBER OF TIMES
                                ''THAT THE FOB RECEIVES LATERAL SUPPORT
        S,                      ''USED FOR A FLAG FOR IDENTIFING THOSE
                                ''BACKORDERS FOR THE FOB THAT THE
                                ''STAGING BASE CAN FILL
        Y,                      ''USED AS A COUNTER THAT CHANGES THE
                                ''IDENTITY OF EACH SB.ORDER(AN ENTITY)
                                ''THAT IS CREATED
        D,                      ''SET EQUAL TO THE FLAG NUMBER OF THE
                                ''BACKORDER THAT IS EITHER BEING
                                ''ADDED OR DESTROYED
        CUST.YEARLY,            ''THE AVERAGE NUMBER OF CUSTOMERS
                                ''PER YEAR AT THE FOB
        SB.CUST.YEAR,           ''THE AVERAGE NUMBER OF CUSTOMERS
                                ''PER YEAR AT THE STAGING BASE
        LAT.SUP,                ''THE TOTAL OF ALL ITEMS THAT ARE
                                ''BEING SHIPPED TO THE FOB FROM
                                ''LATERAL SUPPORT
        TOT.FOB.BO.QTY,         ''THE TOTAL OF ALL OUTSTANDING
                                ''BACKORDERS THAT THE FOB HAS
        TOT.SB.BO.QTY,          ''THE TOTAL OF ALL OUTSTANDING
                                ''BACKORDERS THAT THE STAGING BASE HAS
                                ''ON ORDER
        NO.ORDERS,              ''A COUNTER THAT IDENTIFIES THE NUMBER
                                ''OF TIMES THE FOB INITIATES A STOCK
                                ''REPLENISHMENT ACTION FROM THE
                                ''STAGING BASE
        Z,                      ''A COUNTER THAT CHANGES THE IDENTITY
                                ''OF EACH FOB.ORDER(ENTITY) THAT IS
                                ''CREATED
        TOT.QTY.SHIP            ''THE TOTAL QUANTITY OF ITEMS SHIPPED
                                ''OFF THE SHELF OF THE STAGING BASE
                                ''AND IN THE PIPE TO THE FOB
        AS INTEGER VARIABLES

DEFINE ROT.TIME,            ''THE TOTAL TIME FOR THE FOB TO RECEIVE
                            ''A SHIPMENT OFF THE SHELF OF
                            ''THE STAGING BASE
        BO.ROT.TIME,        ''THE TOTAL TIME FOR THE FOB TO RECEIVE
```

```
                         ''A SHIPMENT THAT WAS BACKORDERED BY
                         ''THE STAGING BASE
       BG.STK.OUT,       ''BEGINNING FOB STOCKOUT TIME
       END.STK.OUT,      ''ENDING FOB STOCKOUT TIME
       STK.OUT.TIME,     ''INTERVAL OF FOB STOCKOUT TIME
       SB.ROT.TIME,      ''REORDER TIME INTERVAL FOR THE STAGING BASE
       SB.BG.STK.OUT,    ''THE TIME THE STAGING BASE STOCK LEVEL WAS
                         ''FIRST <= ZERO
       SB.STK.OUT.TIME,''TOTAL TIME THE STAGING BASE WAS <= ZERO
       F.DD,             ''DAILY DEMAND AT THE FOB
       SB.DD,            ''DAILY DEMAND AT THE STAGING BASE
       CI,               ''UNIT COST OF ITEM
       LAM,              ''CUSTOMERS PER YEAR AT THE FOB DIVIDED BY 365
       SB.LAM,           ''CUSTOMERS PER YEAR AT THE STAGING BASE
                         ''DIVIDED BY 365
       LOT.SIZE,         ''THE QUANTITY DEMAND BY A CUSTOMER--EQUAL
                         ''TO THE ANNUAL DEMAND DIVIDED BY CUSTOMERS
                         ''PER YEAR
       L,                ''INVERSE OF (THE CUSTOMERS PER YEAR AT THE
                         ''STAGING BASE DIVIDED BY 365)
       B,                ''A RANDOM NUMBER TO DETERMINE LATERAL SUPPORT
       K,                ''EQUAL TO THE INVERSE OF (THE CUSTOMERS PER
                         ''YEAR AT THE FOB DIVIDED BY 365)
       SX,               ''EQUAL TO THE CURRENT TIME AT THE SB
       SZ,               ''EQUAL TO THE CURRENT TIME PLUS THE TIME
                         ''BEFORE THE NEXT CUSTOMER AT THE SB
       SY,               ''EQUAL TO THE AMOUNT OF TIME BETWEEN
                         ''CUSTOMERS AT THE SB
       DX,               ''EQUAL TO THE CURRENT TIME AT THE FOB
       DZ,               ''EQUAL TO THE CURRENT TIME PLUS THE TIME
                         ''BEFORE THE NEXT CUSTOMER AT THE FOB
       DY,               ''EQUAL TO THE AMOUNT OF TIME BETWEEN
                         ''CUSTOMERS AT THE FOB
       INTERDICTION      ''A VARIABLE USED TO DETERMINE IF AN FOB
                         ''RESUPPLY EFFORT WAS DESTROYED BY THE ENEMY
       AS REAL VARIABLES


DEFINE ERRC,
       RI                   ''ROUTING IDENTIFIER
       AS ALPHA VARIABLES


THE SYSTEM OWNS AN F.ORDER.SET,
                 A F.BO.SET,
                 A SB.ORD.SET,
                 A LAT.SET


TEMPORARY ENTITIES
     GENERATE LIST ROUTINES
     EVERY FOB.ORDER HAS A SB.QTY.SHIP,
                         A BG.ROT,
                         A FLAG,
```

```
                        A BG.BO.ROT,
                        A FOB.BO.QTY AND
              MAY BELONG TO AN F.ORDER.SET,
                          A F.BO.SET,
                          A LAT.SET

     EVERY SB.ORDER HAS A SB.BO.QTY,
                        A BG.SB.ROT,
                        A END.SB.ROT AND
              MAY BELONG TO AN SB.ORD.SET


DEFINE XX AS AN INTEGER, 1-DIMENSIONAL ARRAY
DEFINE CC AS AN INTEGER, 1-DIMENSIONAL ARRAY
DEFINE DD AS AN INTEGER, 1-DIMENSIONAL ARRAY


TALLY MEAN.ROT.TIME AS THE MEAN,
      SD.ROT.TIME AS THE STD.DEV,
      AND NO.ROT AS THE NUMBER OF ROT.TIME

TALLY MEAN.SB.ROT.TIME AS THE MEAN,
      SD.SB.ROT.TIME AS THE STD.DEV,
      AND NO.SB.ROT AS THE NUMBER OF SB.ROT.TIME

TALLY MEAN.STK.OUT.TIME AS THE MEAN,
      SD.STK.OUT.TIME AS THE STD.DEV,
      AND NO.STK.OUT AS THE NUMBER OF STK.OUT.TIME

TALLY MEAN.BO.ROT.TIME AS THE MEAN,
      SD.BO.ROT.TIME AS THE STD.DEV,
      AND NO.BO.ROT.TIME AS THE NUMBER OF BO.ROT.TIME

TALLY MEAN.SB.STK.OUT.TIME AS THE MEAN,
      SD.SB.STK.OUT.TIME AS THE STD.DEV,
      AND NO.SB.STK.OUT AS THE NUMBER OF SB.STK.OUT.TIME

TALLY NO.REQ AS THE NUMBER OF NO.ORDERS
TALLY FOB.NUM.BO AS THE NUMBER OF NO.FOB.BO
TALLY NO.SUP.LAT AS THE NUMBER OF SUP.LAT
TALLY NO.SUP.DESTROYED AS THE NUMBER OF SUP.DESTROYED

DEFINE TRUE TO MEAN 1
DEFINE FALSE TO MEAN 2

END ''PREAMBLE



MAIN ''BEGIN

'AGAIN'
ADD 1 TO REPS
```

```
LET DA.PT = 0
RESET TOTALS OF ROT.TIME,SB.ROT.TIME,NO.ORDERS AND NO.FOB.BO
RESET TOTALS OF SB.STK.OUT.TIME, BO.ROT.TIME AND STK.OUT.TIME
RESET TOTALS OF SUP.LAT AND SUP.DESTROYED

RESERVE XX(*) AS 100
RESERVE CC(*) AS 100
RESERVE DD(*) AS 100


READ ERRC,RI,CI,F.AD,CUST.YEARLY USING UNIT 7
''PRINT 1 LINE WITH ERRC,RI,CI,F.AD
''      AND CUST.YEARLY THUS
''      ***   ***   ****.**  ****  *****

''LET SB.AD = F.AD/2
  LET SB.AD = F.AD
''LET SB.AD = F.AD * 2
LET SB.AD = SB.AD + F.AD

'UP'
ADD 1 TO DA.PT
LET TIME.V = 0.0
LET TOT.SB.BO.QTY = 0
LET TOT.FOB.BO.QTY = 0
LET LAT.SUP = 0
LET TOT.QTY.SHIP = 0
LET SY = 0.0
LET SZ = 0.0
LET DY = 0.0
LET DZ = 0.0

ACTIVATE A STATS IN 366 DAYS
ACTIVATE A DAY.BEGIN NOW
START SIMULATION

IF DA.PT < 30
   GO 'UP'
ALWAYS

IF REPS < 40
  GO 'AGAIN'
ALWAYS

END  ''MAIN



EVENT DAY.BEGIN   ''BEGIN

''THIS EVENT IS USED TO ACTIVATE THE EOQ PROCESS.  THIS
''EVENT CAN BE EXPANDED IN THE FUTURE TO ACTIVATE OTHER
''PROCESSES SUCH AS THOSE THAT MAY BE USED WITH REPAIRABLES.
```

```
IF ERRC = "XB3"
   ACTIVATE A EOQ NOW
ALWAYS
RETURN

END   ''EVENT DAY.BEGIN



PROCESS EOQ   ''BEGIN

''THIS PROCESS MAKES SURE THAT THE BACKORDER SET AND THE ORDER SET
''OF THE FOB ARE EMPTY BEFORE FURTHER SIMULATION TAKES PLACE.
''THIS PROCESS ALSO CALCULATES SEVERAL OF THE EQUATIONS THAT ARE
''NEEDED FOR THE SIMULATION.  DIFFERENT ROUTING IDENTIFIERS
''WERE USED TO CALCULATE SOME OF THE EQUATIONS FOR THE STAGING
''BASE IN THE EVENT THAT FUTURE SIMULATION MAY BE DONE FOR ONLY
''ONE ROUTING IDENTIFIER OR THE ACTUAL ROUTING IDENTIFIER MAY
''BE USED FOR EACH ITEM BEING SIMULATED.

DEFINE NUMBER AS AN INTEGER VARIABLE

IF F.BO.SET IS NOT EMPTY
   FOR EACH NUMBER OF F.BO.SET WITH FLAG(NUMBER) >= 0
   DO
      REMOVE THIS NUMBER FROM F.BO.SET
   LOOP
ALWAYS

IF F.ORDER.SET IS NOT EMPTY
   FOR EACH NUMBER OF F.ORDER.SET WITH FLAG(NUMBER) >= 0
   DO
      REMOVE THIS NUMBER FROM F.ORDER.SET
   LOOP
ALWAYS

IF ERRC = "XB3"
   LET LAM = CUST.YEARLY/365
   LET LOT.SIZE = F.AD/CUST.YEARLY
   LET FOB.EOQ = (5.9*SQRT.F(F.AD*CI))/CI
   LET SB.EOQ = (5.9*SQRT.F(SB.AD*CI))/CI
   LET FOB.OSTQ = (F.AD/365)*10.000
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*10.000))
   LET FOB.RE.PT = FOB.OSTQ + FOB.SFTY.STK
   IF DA.PT = 30
''       PRINT 2 LINES WITH CO,CH,SB.AD,FOB.EOQ,SB.EOQ,FOB.OSTQ,
''        FOB.RE.PT AND FOB.SFTY.STK THUS
''   CO     CH    SB.AD   FOB.EOQ   SB.EOQ   FOB.OSTQ   FOB.RE.PT   FOB.SFTY.STK
'' **.**  **.**   ****    ****.**   ****       ****       ****          ****
   ALWAYS
     IF RI = "AKZ"
        LET SB.OSTQ = (SB.AD/365)*63
```

```
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*63))
ALWAYS

IF RI = 'B14'
   LET SB.OSTQ = (SB.AD/365)*40
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*40))
ALWAYS

IF RI = 'FFZ'
 ''LET SB.OSTQ = (SB.AD/365)*49
 ''LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*49))
 ''LET SB.OSTQ = (SB.AD/365)*60
 ''LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*60))
 ''LET SB.OSTQ = (SB.AD/365)*30
 ''LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*30))
   LET SB.OSTQ = (SB.AD/365)*15
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*15))
ALWAYS

IF RI = 'FHZ'
   LET SB.OSTQ = (SB.AD/365)*41
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*41))
ALWAYS

IF RI = 'FLZ'
   LET SB.OSTQ = (SB.AD/365)*45
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*45))
ALWAYS

IF RI = 'FPZ'
   LET SB.OSTQ = (SB.AD/365)*54
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*54))
ALWAYS

IF RI = 'GAO'
   LET SB.OSTQ = (SB.AD/365)*64
   LET SB.SFTY.STK = SQRT.F (3*((SB.AD/365)*64))
ALWAYS

IF RI = 'GNO'
   LET SB.OSTQ = (SB.AD/365)*67
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*67))
ALWAYS

IF RI = 'GSA'
   LET SB.OSTQ = (SB.AD/365)*59
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*59))
ALWAYS

IF RI = 'S9C'
   LET SB.OSTQ = (SB.AD/365)*52
   LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*52))
ALWAYS
```

```
    IF RI = "S9E"
       LET SB.OSTQ = (SB.AD/365)*42
       LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*42))
    ALWAYS

    IF RI = "S9G"
       LET SB.OSTQ = (SB.AD/365)*38
       LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*38))
    ALWAYS

    IF RI = "S9I"
       LET SB.OSTQ = (SB.AD/365)*58
       LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*58))
    ALWAYS

    IF RI = "S9T"
       LET SB.OSTQ = (SB.AD/365)*53
       LET SB.SFTY.STK = SQRT.F(3*((SB.AD/365)*53))
    ALWAYS

    LET SB.RE.PT = SB.OSTQ + SB.SFTY.STK
    IF DA.PT = 30

''PRINT 2 LINES WITH SB.OSTQ,SB.SFTY.STK AND SB.RE.PT THUS
'' SB.OSTQ    SB.SFTY.STK   SB.RE.PT
''  ****        ******       *****
    ALWAYS
ALWAYS

SCHEDULE A STAGING.BASE NOW
SCHEDULE A FORWARD.OPERATING.BASE NOW

RETURN

END  ''EOQ PROCESS




PROCESS FORWARD.OPERATING.BASE  ''BEGIN

''THIS PROCESS INITIALIZES THE STOCK LEVELS FOR THE STAGING
''BASE AND THE FOB.  INFORMATION CONCERNING THE STOCK LEVELS
''CAN BE PRINTED OUT.  THE REORDER POINT IS CHECKED DAILY TO
''SEE IF A FOB.ORDER SHOULD BE CREATED.  THE PROCESS FOB.DEMAND
''IS ACTIVATED DAILY.  IF THE FOB STOCK LEVEL IS <= ZERO, A
''CHECK.STK.OUT PROCESS IS ACTIVATED.  K IS INITIALIZED HERE
''BUT IS USED IN THE FOB.DEMAND PROCESS.

DEFINE NUMBER AS AN INTEGER VARIABLE

LET Z = 0

IF FOB.RE.PT > FOB.EOQ
```

```
   LET FOB.STK.LV = FOB.RE.PT + FOB.SFTY.STK
ELSE
   LET FOB.STK.LV = FOB.SFTY.STK + FOB.EOQ
ALWAYS

IF SB.RE.PT > SB.EOQ
   LET SB.STK.LV = SB.RE.PT + SB.SFTY.STK
ELSE
   LET SB.STK.LV = SB.SFTY.STK + SB.EOQ
ALWAYS
LET 1.STK.LV.TEST = TRUE

IF DA.PT = 1
''PRINT 8 LINES WITH REPS,DA.PT, SB.STK.LV, FOB.STK.LV, SB.RE.PT,
''FOB.RE.PT, SB.EOQ AND FOB.EOQ THUS

''THIS REPETITION ***     DATA POINT ***

''BEGINNING STOCK LEVEL IS **** FOR SB, AND **** FOR FOB

''REORDER POINT IS **** FOR SB, AND **** FOR FOB
''REORDER QUANTITY IS **** FOR SB, AND **** FOR FOB

ALWAYS

LET K = 1/LAM

FOR DAY = 1 TO 365
DO
   ACTIVATE A FOB.DEMAND NOW

IF FOB.STK.LV + TOT.QTY.SHIP + TOT.FOB.BO.QTY + LAT.SUP <= FOB.RE.PT
'' PRINT 1 LINE WITH FOB.STK.LV,TOT.QTY.SHIP,
''      TOT.FOB.BO.QTY, LAT.SUP AND FOB.RE.PT THUS
''**** + **** + **** + **** <=  ****   SO A FOB.RESTOCK WAS ACTIVATED
      ADD 1 TO Z
      CREATE AN FOB.ORDER CALLED XX(Z)
      LET NUMBER = XX(Z)
      LET BG.ROT(NUMBER) = TIME.V
      ACTIVATE AN FOB.RESTOCK(NUMBER) NOW
ALWAYS

''THE PURPOSE OF 1.STK.LV.TEST IS TO ALLOW BEGINNING TIME OF A
''STOCK OUT TO BE INITIALIZED AND NOT RESET UNTIL AFTER RECEIPT
''OF A SHIPMENT.
IF 1.STK.LV.TEST = TRUE
    IF FOB.STK.LV <= 0
       LET BG.STK.OUT = TIME.V
       LET 1.STK.LV.TEST = FALSE
       ACTIVATE A CHECK.STK.OUT NOW
    ALWAYS
ALWAYS
WAIT 1 DAY
LOOP
```

```
RETURN

END ''PROCESS FORWARD.OPERATING.BASE



PROCESS FOB.DEMAND        ''BEGIN

''THIS PROCESS FIGURES THE TIME BETWEEN CUSTOMERS AT THE FOB.
''SINCE DX WILL BE GREATER THAN DZ THE FIRST TIME, DY WILL
''BE EQUAL TO THE TIME BEFORE THE NEXT CUSTOMER, AND DZ WILL
''BE EQUAL TO THE CURRENT TIME PLUS THE TIME WHEN THE NEXT
''CUSTOMER ARRIVES.  THIS PROCESS WILL WAIT FOR THE NEXT
''CUSTOMER TO ARRIVE AND THEN SUBTRACT THE DAILY DEMAND FROM
''THE STOCK LEVEL.  SINCE DX IS THE CURRENT TIME, DX WILL NOT
''BE GREATER THAN DZ UNTIL THE NEXT CUSTOMER ARRIVES.

LET DX = TIME.V
IF DX > DZ
   LET DY = EXPONENTIAL.F(K,8)
   LET DZ = DX + DY
   WAIT DY DAYS
   IF TIME.V < 365
      LET F.DD = LOT.SIZE
      SUBTRACT F.DD FROM FOB.STK.LV
''    PRINT 2 LINES WITH TIME.V,F.DD AND FOB.STK.LV THUS
''DAY ***
''  F.DD = ****                          FOB.STK.LV = ****
   ALWAYS
ALWAYS
RETURN

END '' PROCESS FOB.DEMAND



PROCESS FOB.RESTOCK(NUMBER)  ''BEGIN

''THIS PROCESS DETERMINES WHERE THE FOB WILL RECEIVE ITS STOCK
''FROM.  THE FIRST 'IF' IS USED IF THE STAGING BASE HAS ENOUGH
''STOCK TO SHIP THE ENTIRE FOB EOQ.  THE SUPPLIES DESTROYED
''PROCESS IS THEN ACTIVATED FOR THAT SHIPMENT.  IF THE STAGING
''BASE DOES NOT HAVE ENOUGH STOCK TO SHIP THE ENTIRE FOB EOQ
''BUT DOES HAVE SOME STOCK ON THE SHELF, THE SECOND 'IF' IS
''USED.  THE STAGING BASE SHIPS THE STOCK ON HAND AND ACTIVATES
''THE SUPPLIES DESTROYED PROCESS TO SEE IF THAT SHIPMENT IS
''DESTROYED.  THE REMAINING QUANTITY IS SET EQUAL TO THE
''BACKORDER QUANTITY AND IS ADDED TO THE TOTAL AMOUNT OF LATERAL
''SUPPORT IN THE PIPE.  THE LATERAL SUPPORT PROCESS IS ACTIVATED
''TO DETERMINE IF THAT QUANTITY WILL COME FROM LATERAL SUPPORT
''OR BE BACKORDERED TO THE CONUS.  IF THE STAGING BASE HAS NO
''STOCK ON HAND THE FOB EOQ IS ADDED TO THE TOTAL AMOUNT OF
```

```
''LATERL SUPPORT IN THE PIPE.  THE LATERAL SUPPORT PROCESS IS
''ACTIVATED TO DETERMINE IF THAT QUANTITY WILL COME FROM LATERAL
''SUPPORT OR BE BACKORDERED TO THE CONUS.

DEFINE NUMBER AS AN INTEGER VARIABLE

ADD 1 TO NO.ORDERS

''PRINT 1 LINE THUS
''FOB RESTOCK INITIATED
IF SB.STK.LV >= FOB.EOQ
''PRINT 1 LINE THUS
''FOB BEING RESUPPLIED FROM STAGING BASE
   LET SB.QTY.SHIP(NUMBER) = FOB.EOQ
   ADD SB.QTY.SHIP(NUMBER) TO TOT.QTY.SHIP
   FILE THIS NUMBER IN F.ORDER.SET
   SUBTRACT FOB.EOQ FROM SB.STK.LV
   ACTIVATE A  SUPPLIES.DESTROYED(NUMBER) NOW
ELSE
   IF SB.STK.LV > 0 AND SB.STK.LV < FOB.EOQ
      LET FOB.BO.QTY(NUMBER) = FOB.EOQ - SB.STK.LV
      LET BG.BO.ROT(NUMBER) = TIME.V
      LET SB.QTY.SHIP(NUMBER) = SB.STK.LV
      ADD FOB.BO.QTY(NUMBER) TO LAT.SUP
      ADD SB.QTY.SHIP(NUMBER) TO TOT.QTY.SHIP
      FILE THIS NUMBER IN F.ORDER.SET
''    PRINT 1 LINE WITH SB.QTY.SHIP(NUMBER) AND
''       FOB.BO.QTY(NUMBER) THUS
''    SB.QTY.SHIP OFF SHELF IS ****     FOB.BO.QTY IS ****
      LET SB.STK.LV = 0
      ACTIVATE A LATERAL.CHECK(NUMBER) NOW
      ACTIVATE A SUPPLIES.DESTROYED(NUMBER) NOW
   ELSE
      IF SB.STK.LV <= 0
         LET FOB.BO.QTY(NUMBER) = FOB.EOQ
         ADD FOB.BO.QTY(NUMBER) TO LAT.SUP
         LET BG.BO.ROT(NUMBER) = TIME.V
''       PRINT 1 LINE WITH TOT.FOB.BO.QTY AND FOB.EOQ THUS
''  SB.STK.LV < 0   TOT.FOB.BO.QTY = ****    FOB.EOQ = ****
         ACTIVATE A LATERAL.CHECK(NUMBER) NOW
      ALWAYS
   ALWAYS
ALWAYS
RETURN

END  ''FOB RESTOCK




PROCESS SUPPLIES.DESTROYED(NUMBER)   ''BEGIN

''THIS PROCESS WAITS FOR THE SHIPMENT FROM THE STAGING BASE TO
''ARRIVE AT THE FOB AND THEN CHECKS TO SEE IF THE SHIPMENT IS
```

```
''DESTROYED.  IF IT IS DESTROYED, IT IS SUBTRACTED FROM THE
''AMOUNT IN THE PIPE FROM THE STAGING BASE.  OTHERWISE IT IS
''ADDED TO THE FOB STOCK LEVEL.

DEFINE NUMBER AS AN INTEGER VARIABLE
WAIT LOG.NORMAL.F(10.00,5.0,2)DAYS
IF TIME.V < 366

LET INTERDICTION = RANDOM.F(7)

IF INTERDICTION <.00
''IF INTERDICTION <.10
''IF INTERDICTION <.20
   ADD 1 TO SUP.DESTROYED
'' PRINT 1 LINE WITH TIME.V THUS
'' SUPPLIES(EOQ) DESTROYED IN ROUTE BY ENEMY ON DAY ***
   REMOVE THIS NUMBER FROM F.ORDER.SET
   SUBTRACT SB.QTY.SHIP(NUMBER) FROM TOT.QTY.SHIP
   LET SB.QTY.SHIP(NUMBER) = 0
   IF THIS NUMBER IS NOT IN F.BO.SET
      IF THIS NUMBER IS NOT IN LAT.SET
         DESTROY THIS FOB.ORDER CALLED NUMBER
      ALWAYS
   ALWAYS
ELSE
   ADD SB.QTY.SHIP(NUMBER) TO FOB.STK.LV
   SUBTRACT SB.QTY.SHIP(NUMBER) FROM TOT.QTY.SHIP
   LET END.ROT = TIME.V
   LET ROT.TIME = END.ROT - BG.ROT(NUMBER)
   REMOVE THIS NUMBER FROM F.ORDER.SET
''PRINT 1 LINE WITH TIME.V,SB.QTY.SHIP(NUMBER) AND TOT.QTY.SHIP THUS
''DAY ***  RECEIVED **** FROM STAGING BASE   TOTAL ON ORDER IS *****
   IF THIS NUMBER IS NOT IN F.BO.SET
      IF THIS NUMBER IS NOT IN LAT.SET
         DESTROY THIS FOB.ORDER CALLED NUMBER
      ALWAYS
   ALWAYS
 ALWAYS
ALWAYS
RETURN

END  ''SUPPLIES.DESTROYED



PROCESS LATERAL.CHECK(NUMBER)    ''BEGIN

''THIS PROCESS CHECKS TO SEE IF ANY LATERAL SUPPORT IS AVAILABLE.
''IF THE FOB IS GOING TO RECEIVE LATERAL SUPPORT, IT WAITS FOR THE
''SHIPMENT TO ARRIVE AND THEN DETERMINES IF IT IS DESTROYED OR
''ADDED TO THE STOCK LEVEL.  IF LATERAL SUPPORT IS NOT AVAILABLE,
''THE QUANTITY IS SUBTRACTED FROM THE TOTAL LATERAL SUPPORT IN
''THE PIPE AND IS ADDED TO THE TOTAL FOB BACKORDER QUANTITY.
```

```
''SINCE THE STAGING BASE LOOKS AT THIS TOTAL QUANTITY, IT WILL
''FILL THESE BACKORDERS AS STOCK BECOMES AVAILABLE.

DEFINE NUMBER AS AN INTEGER VARIABLE

LET B = RANDOM.F(6)
IF B > 1.00
''IF B > .90
''IF B > .80
'' PRINT 1 LINE THUS
'' FOB BEING RESUPPLIED FROM LATERAL SUPPORT
   FILE THIS NUMBER IN LAT.SET
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN LAT.SET
   WAIT LOG.NORMAL.F(10.00,5.0,2)DAYS
   IF TIME.V < 366
      LET INTERDICTION = RANDOM.F(6)
''    PRINT 1 LINE WITH INTERDICTION THUS
''       INTERDICTION NUMBER WAS .*********
    IF INTERDICTION < .00
    ''IF INTERDICTION < .10
  ''IF INTERDICTION < .20
         REMOVE FIRST NUMBER FROM LAT.SET
''       PRINT 1 LINE WITH TIME.V AND FOB.BO.QTY(NUMBER) THUS
''       DAY ***   LATERAL SUPPORT ITEMS *** DESTROYED
''       LIST ATTRIBUTES OF EACH FOB.ORDER IN LAT.SET
         SUBTRACT FOB.BO.QTY(NUMBER) FROM LAT.SUP
         ADD 1 TO SUP.DESTROYED
      ELSE
''        PRINT 1 LINE THUS
''          NO LATERAL SUPPORT
         SUBTRACT FOB.BO.QTY(NUMBER) FROM LAT.SUP
         ADD 1 TO SUP.LAT
         ADD FOB.BO.QTY(NUMBER) TO FOB.STK.LV
      ALWAYS
   ALWAYS
ELSE
   ADD FOB.BO.QTY(NUMBER) TO TOT.FOB.BO.QTY
   ADD 1 TO NO.FOB.BO
   SUBTRACT FOB.BO.QTY(NUMBER) FROM LAT.SUP
   FILE THIS NUMBER IN F.BO.SET
ALWAYS
RETURN

END   ''LATERAL.CHECK


PROCESS CHECK.STK.OUT     ''BEGIN

''WHEN THE FOB STOCK LEVEL IS GREATER THAN ZERO, THE CLOCK IS
''STOPPED AND THE OUT OF STOCK TIME IS DETERMINED.

IF FOB.STK.LV > 0
```

```
    LET END.STK.OUT = TIME.V
    LET STK.OUT.TIME = END.STK.OUT - BG.STK.OUT
    LET 1.STK.LV.TEST = TRUE
ELSE
    IF TIME.V < 365
       SCHEDULE A CHECK.STK.OUT IN 1 DAY
    ELSE
       IF TIME.V = 365
          LET END.STK.OUT = TIME.V
          LET STK.OUT.TIME = END.STK.OUT - BG.STK.OUT
          LET 1.STK.LV.TEST = TRUE
       ALWAYS
    ALWAYS
ALWAYS
RETURN

END ''PROCESS CHECK.STK.OUT




PROCESS STAGING.BASE   ''BEGIN

''THIS PROCESS BEGINS BY DETERMINING THE NUMBER OF CUSTOMERS
''PER YEAR AT THE STAGING BASE.  THIS PROCESS IS THE SAME AS
''THE FORWARD OPERATING BASE PROCESS SINCE IT EXAMINES THE
''REORDER POINT AND THE OUT OF STOCK CONDITION DAILY.  IT ALSO
''ACTIVATES THE SB.DEMAND PROCESS DAILY.

DEFINE LONG AS AN INTEGER VARIABLE

LET 2.STK.LV.TEST = TRUE
''LET SB.CUST.YEAR = CUST.YEARLY/2
LET SB.CUST.YEAR = CUST.YEARLY
''LET SB.CUST.YEAR = CUST.YEARLY * 2

LET SB.LAM = SB.CUST.YEAR/365
LET S = 1
LET Y = 0
LET L = 1/SB.LAM
LET TEST.1 = TRUE

FOR DAY =  1 TO 365
    DO
    ACTIVATE A SB.DEMAND NOW

    IF SB.STK.LV + TOT.SB.BO.QTY - TOT.FOB.BO.QTY <= SB.RE.PT
''PRINT 1 LINE WITH SB.STK.LV,TOT.SB.BO.QTY,TOT.FOB.BO.QTY
'' AND SB.RE.PT THUS
''**** + **** - **** <= ****   SO A STAGING BASE RESTOCK WAS ACTIVATED
       ADD 1 TO Y
       CREATE AN SB.ORDER CALLED DD(Y)
       LET LONG = DD(Y)
```

```
      FILE THIS LONG IN THE SB.ORD.SET
      LET BG.SB.ROT(LONG) = TIME.V
      LET SB.BO.QTY(LONG) = SB.EOQ
      ADD SB.BO.QTY(LONG) TO TOT.SB.BO.QTY
      ACTIVATE AN SB.RESTOCK(LONG) NOW
   ALWAYS
   IF 2.STK.LV.TEST = TRUE
      IF SB.STK.LV <= 0
         LET SB.BG.STK.OUT = TIME.V
         LET 2.STK.LV.TEST = FALSE
         ACTIVATE A SB.CHECK.STK.OUT NOW
      ALWAYS
   ALWAYS
   WAIT 1 DAY
   LOOP
RETURN

END ''PROCESS STAGING.BASE




PROCESS SB.DEMAND ''BEGIN

''THIS PROCESS FIGURES THE TIME BETWEEN CUSTOMERS AT THE
''STAGING BASE.  SINCE DX WILL BE GREATER THAN DZ THE FIRST
''TIME, DY WILL BE EQUAL TO THE TIME BEFORE THE NEXT CUSTOMER,
''AND DZ  WILL BE EQUAL TO THE CURRENT TIME PLUS THE TIME
''WHEN THE NEXT CUSTOMER ARRIVES.  THIS PROCESS WILL WAIT
''FOR THE NEXT CUSTOMER TO ARRIVE AND THEN SUBTRACT THE DAILY
''DEMAND FROM THE STOCK LEVEL.  SINCE DX IS THE CURRENT TIME,
''DX WILL NOT BE GREATER THAN DZ UNTIL THE NEXT CUSTOMER
''ARRIVES.

LET SX = TIME.V
IF SX > SZ
   LET SY = EXPONENTIAL.F(L,5)
   LET SZ = SX + SY
   WAIT SY DAYS
   IF TIME.V <= 365
      LET SB.DD = LOT.SIZE
      SUBTRACT SB.DD FROM SB.STK.LV
''    PRINT 2 LINES WITH TIME.V, SB.DD AND SB.STK.LV THUS
''DAY ***
''  SB.DD = ****                                  SB.STK.LV = ****
   ALWAYS
ALWAYS
RETURN

END  '' PROCESS SB.DEMAND
```

```
PROCESS SB.CHECK.STK.OUT   ''BEGIN

''WHEN THE STAGING BASE STOCK LEVEL IS GREATER THAN ZERO, THE
''CLOCK IS STOPPED AND THE OUT OF STOCK TIME IS DETERMINED.

IF SB.STK.LV > 0
   LET END.STK.OUT = TIME.V
   LET SB.STK.OUT.TIME = END.STK.OUT - SB.BG.STK.OUT
   LET 2.STK.LV.TEST = TRUE
ELSE
   IF TIME.V < 365
      SCHEDULE A SB.CHECK.STK.OUT IN 1 DAY
   ELSE
      IF TIME.V = 365
         LET END.STK.OUT = TIME.V
         LET SB.STK.OUT.TIME = END.STK.OUT - SB.BG.STK.OUT
         LET 2.STK.LV.TEST = TRUE
      ALWAYS
   ALWAYS
ALWAYS

RETURN

END   ''PROCESS SB.CHECK.STK.OUT




PROCESS SB.RESTOCK(LONG) ''BEGIN

''THIS PROCESS WAITS FOR THE SHIPMENT TO ARRIVE AT THE
''STAGING BASE FROM THE CONUS.  THE DIFFERENT ROUTING
''IDENTIFIERS WERE USED TO ALLOW THE ACTUAL SOURCE OF THE
''ITEM TO BE USED IF DESIRED.  AFTER THE SHIPMENT ARRIVES
''AT THE STAGING BASE, THE STAGING BASE CHECKS TO SEE IF THE
''FOB HAD ANY BACKORDERS WHILE THE STAGING BASE WAS OUT OF
''STOCK.  IF THE STAGING BASE CAN FILL ALL OF THE BACKORDERS
''IT DOES SO AND WAITS FOR THE SHIPMENT TO ARRIVE AT THE FOB
''BEFORE ACTIVATING THE BACKORDERED ADDED PROCESS.  IF THE
''STAGING BASE CANNOT FILL THE TOTAL AMOUNT ON BACKORDER, IT
''WILL FILL THE BACKORDERS IN THE ORDER THEY WERE CREATED.
''WHEN THE STAGING BASE REACHES A BACKORDER IT CANNOT FILL,
''THE STAGING BASE DOES NOT CONSIDER ANY OTHER BACKORDERS.
''SINCE SEVERAL BACKORDERS MAY HAVE BEEN FILLED AT THE SAME
''TIME, IT IS ASSUMED THEY WERE ALL INCLUDED IN THE SAME
''SHIPMENT.  THIS PROCESS WAITS FOR THAT SHIPMENT TO ARRIVE
''AT THE FOB AND THEN ACTIVATES THE BACKORDER ADDED PROCESS.

DEFINE NUMBER,LONG AS INTEGER VARIABLES

''PRINT 1 LINE WITH TIME.V THUS
''SB RESTOCK INITIATED DAY ***
IF RI = "AKZ"
```

```
   WAIT LOG.NORMAL.F(63.0,22.8,4)DAYS
ALWAYS

IF RI = "B14"
   WAIT LOG.NORMAL.F(40.0,6.4,4)DAYS
ALWAYS

IF RI = "FFZ"
 ''WAIT LOG.NORMAL.F(49.0,33.1,4)DAYS
 ''WAIT LOG.NORMAL.F(60.0,20.0,4)DAYS
 ''WAIT LOG.NORMAL.F(30.0,20.0,4)DAYS
   WAIT LOG.NORMAL.F(15.0,10.0,4)DAYS
ALWAYS

IF RI = "FHZ"
   WAIT LOG.NORMAL.F(41.0,22.0,4)DAYS
ALWAYS

IF RI = "FLZ"
   WAIT LOG.NORMAL.F(45.0,37.7,4)DAYS
ALWAYS

IF RI = "FPZ"
   WAIT LOG.NORMAL.F(54.0,25.7,4)DAYS
ALWAYS

IF RI = "GAO"
   WAIT LOG.NORMAL.F(64.0,20.4,4)DAYS
ALWAYS

IF RI = "GNO"
   WAIT LOG.NORMAL.F(67.0,21.3,4)DAYS
ALWAYS

IF RI = "GSA"
   WAIT LOG.NORMAL.F(59.0,18.8,4)DAYS
ALWAYS

IF RI = "S9C"
   WAIT LOG.NORMAL.F(52.0,23.4,4)DAYS
ALWAYS

IF RI = "S9E"
   WAIT LOG.NORMAL.F(42.0,20.8,4)DAYS
ALWAYS

IF RI = "S9G"
   WAIT LOG.NORMAL.F(38.0,21.5,4)DAYS
ALWAYS

IF RI = "S9I"
   WAIT LOG.NORMAL.F(58.0,26.2,4)DAYS
ALWAYS
```

```
IF RI = "S9T"
   WAIT LOG.NORMAL.F(53.0,15.3,4)DAYS
ALWAYS

IF TIME.V < 366
 LET TEST.2 = TRUE
 ADD SB.BO.QTY(LONG) TO SB.STK.LV
 SUBTRACT SB.BO.QTY(LONG) FROM TOT.SB.BO.QTY
 LET END.SB.ROT(LONG) = TIME.V
 LET SB.ROT.TIME = END.SB.ROT(LONG) - BG.SB.ROT(LONG)
''PRINT 1 LINE WITH SB.BO.QTY(LONG),TIME.V AND SB.STK.LV THUS
'' STAGING BASE RECEIVED **** ON DAY ***     SB.STK.LV IS NOW ****
 REMOVE THIS LONG FROM SB.ORD.SET
 DESTROY THIS SB.ORDER CALLED LONG
 IF TOT.FOB.BO.QTY > 0 AND TOT.FOB.BO.QTY < SB.STK.LV
   LET SB.STK.LV = SB.STK.LV - TOT.FOB.BO.QTY
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
   FOR EACH NUMBER OF F.BO.SET WITH FLAG(NUMBER) = 0
      DO
         ADD FOB.BO.QTY(NUMBER) TO TOT.QTY.SHIP
         SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.FOB.BO.QTY
         LET FLAG(NUMBER) = S
      LOOP
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
   ADD 1 TO S
   WAIT LOG.NORMAL.F(10.000,5.0,2)DAYS
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
   ACTIVATE A BO.ADDED.FOB NOW
 ELSE
   IF TOT.FOB.BO.QTY > SB.STK.LV AND SB.STK.LV > 0
''    LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
      FOR EACH NUMBER OF F.BO.SET WITH FLAG(NUMBER) = 0
        DO
          IF TEST.2 = TRUE
            IF SB.STK.LV > FOB.BO.QTY(NUMBER)
               LET SB.STK.LV = SB.STK.LV - FOB.BO.QTY(NUMBER)
               ADD FOB.BO.QTY(NUMBER) TO TOT.QTY.SHIP
               SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.FOB.BO.QTY
               LET FLAG(NUMBER) = S
               LET TEST.1 = FALSE
            ELSE
               LET TEST.2 = FALSE
            ALWAYS
          ALWAYS
        LOOP
''    LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
      IF TEST.1 = FALSE
         ADD 1 TO S
         LET TEST.1 = TRUE
         WAIT LOG.NORMAL.F(10.00,5.0,2)DAYS
''       LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
         ACTIVATE A BO.ADDED.FOB NOW
      ALWAYS
   ALWAYS
```

```
 ALWAYS
ALWAYS
RETURN

END  '' SB.RESTOCK PROCESS




PROCESS BO.ADDED.FOB   ''BEGIN

''THIS PROCESS CHECKS TO SEE IF THE BACKORDER SHIPMENT
''IS DESTROYED UPON REACHING THE FOB.  IF IT IS NOT, IT
''IS ADDED TO THE FOB STOCK LEVEL.  IF THE SHIPMENT
''IS TO BE DESTROYED, THE BACKORDER DESTROYED PROCESS
''IS ACTIVATED.

DEFINE NUMBER AS AN INTEGER VARIABLE

IF TIME.V < 366
 LET INTERDICTION = RANDOM.F(6)
 IF INTERDICTION < .00
''IF INTERDICTION < .10
''IF INTERDICTION < .20
''    PRINT 1 LINE THUS
''SB SHIPMENT DESTROYED BY ENEMY
     ACTIVATE A BO.DESTROYED NOW
 ELSE
''   PRINT 1 LINE WITH TIME.V THUS
''   BACKORDER ADDED ON DAY ***
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
   LET END.ROT = TIME.V
   REMOVE FIRST NUMBER FROM F.BO.SET
   ADD FOB.BO.QTY(NUMBER) TO FOB.STK.LV
   SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.QTY.SHIP
   LET BO.ROT.TIME = END.ROT - BG.BO.ROT(NUMBER)
   LET D = FLAG(NUMBER)
   IF NUMBER IS NOT IN F.ORDER.SET
      IF NUMBER IS NOT IN LAT.SET
         DESTROY THIS FOB.ORDER CALLED NUMBER
      ALWAYS
   ALWAYS
   IF F.BO.SET IS NOT EMPTY
      FOR EACH NUMBER OF F.BO.SET WITH FLAG(NUMBER) = D
        DO
          REMOVE THIS NUMBER FROM F.BO.SET
          ADD FOB.BO.QTY(NUMBER) TO FOB.STK.LV
          SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.QTY.SHIP
          LET BO.ROT.TIME = END.ROT - BG.BO.ROT(NUMBER)
        LOOP
   ALWAYS
'' LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
 ALWAYS
ALWAYS
```

```
RETURN

END ''BO.ADDED.FOB PROCESS



PROCESS BO.DESTROYED  ''BEGIN

''THIS PROCESS REMOVES THOSE BACKORDERS FROM THE SYSTEM
''THAT WERE DESTROYED.

DEFINE NUMBER AS AN INTEGER VARIABLE

''PRINT 1 LINE WITH TIME.V THUS
''BO DESTROYED ON DAY ***
''LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
REMOVE FIRST NUMBER FROM F.BO.SET
SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.QTY.SHIP
LET D = FLAG(NUMBER)
IF NUMBER IS NOT IN F.ORDER.SET
   IF NUMBER IS NOT IN LAT.SET
      DESTROY THIS FOB.ORDER CALLED NUMBER
   ALWAYS
ALWAYS
IF F.BO.SET IS NOT EMPTY
   FOR EACH NUMBER OF F.BO.SET WITH FLAG(NUMBER) = D
    DO
      REMOVE THIS NUMBER FROM F.BO.SET
      SUBTRACT FOB.BO.QTY(NUMBER) FROM TOT.QTY.SHIP
    LOOP
''LIST ATTRIBUTES OF EACH FOB.ORDER IN F.BO.SET
ALWAYS
RETURN

END  ''PROCESS BO.DESTROYED



PROCESS STATS  ''BEGIN

''THIS PROCESS PRINTS OUT THE STATISTICS THAT ARE COLLECTED
''DURING THE SIMULATION.

DEFINE NEW.NO.REQ,NEW.NO.ROT,NEW.NO.SB.ROT,NEW.NO.STK.OUT,
     NEW.NO.BO.ROT.TIME, NEW.NO.FOB.BO, NEW.NO.SUP.LAT,
     NEW.NO.SUP.DESTROYED AND NEW.NO.SB.STK.OUT AS REAL VARIABLES

LET NEW.NO.SUP.LAT = NO.SUP.LAT/DA.PT
LET NEW.NO.DESTROYED = NO.SUP.DESTROYED/DA.PT
LET NEW.NO.REQ = NO.REQ/DA.PT
LET NEW.NO.ROT = NO.ROT/DA.PT
LET NEW.NO.SB.ROT = NO.SB.ROT/DA.PT
```

```
LET NEW.NO.STK.OUT = NO.STK.OUT/DA.PT
LET NEW.NO.SB.STK.OUT = NO.SB.STK.OUT/DA.PT
LET NEW.NO.BO.ROT.TIME = NO.BO.ROT.TIME/DA.PT
LET NEW.NO.FOB.BO = FOB.NUM.BO/DA.PT

IF DA.PT = 30

SKIP 4 OUTPUT LINES


PRINT 1 LINE WITH REPS AND DA.PT THUS
ITEM ***    DATA POINT ***
PRINT 7 LINES WITH MEAN.ROT.TIME, SD.ROT.TIME,
                   MEAN.SB.ROT.TIME, SD.SB.ROT.TIME,
                   MEAN.STK.OUT.TIME, SD.STK.OUT.TIME,
                   MEAN.SB.STK.OUT.TIME, SD.SB.STK.OUT.TIME,
                   MEAN.BO.ROT.TIME AND SD.BO.ROT.TIME THUS

                                     MEAN         STD DEV
FOB REORDER TIME                   ****.***     ******.***
STAGING BASE REORDER TIME          ****.***     ******.***
TIME FOB OUT OF STOCK              ****.***     ******.***
TIME STAGING BASE OUT OF STOCK     ****.***     ******.***
TIME OF FOB BACK-ORDERS            ****.***     ******.***

SKIP TWO OUTPUT LINES

PRINT 9 LINES WITH NEW.NO.SUP.LAT,
                   NEW.NO.DESTROYED,
                   NEW.NO.REQ,
                   NEW.NO.ROT,
                   NEW.NO.SB.ROT,
                   NEW.NO.STK.OUT,  ''NO. OF TIMES FOB OUT OF STK
                   NEW.NO.SB.STK.OUT,
                   NEW.NO.BO.ROT.TIME,
                   NEW.NO.FOB.BO
                   THUS


FOB RECEIVED LATERAL SUPPORT ***.** TIMES
FOB SHIPMENTS DESTROYED BY ENEMY WAS ***.**
FOB INITIATED ****.** ORDERS FROM SB AND RECEIVED ***.** ORDERS
STAGING BASE INITIATED ****.** REORDERS
FOB WAS OUT OF STOCK ****.** TIMES
STAGING BASE WAS OUT OF STOCK ***.** TIMES
FOB RECEIVED ****.** BACKORDERS AND INITIATED ****.** BACKORDERS

SKIP THREE OUTPUT LINES
ALWAYS
RETURN


END   ''PROCESS STATS
```

Appendix B: Simulation Program of the Current Resupply Model

```
PREAMBLE  ''BEGIN

EVENT NOTICES INCLUDE DAY.BEGIN   ''CURRENT RESUPPLY SYSTEM BEGINS

PROCESSES INCLUDE
          FORWARD.OPERATING.BASE, ''FORWARD OPERATING BASE
          FOB.RESTOCK,            ''FORWARD OPERATING BASE RESTOCK
          CHECK.STK.OUT,          ''CHECK STOCK OUT AT FOB
          SUPPLIES.DESTROYED,     ''SUPPLIES DESTROYED AT FOB
          EOQ,                    ''ECONOMIC ORDER QUANTITY
          LATERAL.CHECK,          ''LATERAL SUPPORT CHECK
          FOB.DEMAND,             ''FOB DEMAND
          STATS                   ''STATISTICS

          EVERY FOB.RESTOCK HAS A N1
          EVERY LATERAL.CHECK HAS A B1
          EVERY SUPPLIES.DESTROYED HAS A D1
          EVERY FORWARD.OPERATING.BASE HAS A J1


DEFINE FOB.STK.LV,         ''FOB STOCK LEVEL
       FOB.EOQ,            ''FOB ECONOMIC ORDER QUANTITY
       FOB.RE.PT,          ''REORDER POINT FOR AN ITEM AT THE FOB
       F.AD,               ''ANNUAL DEMAND FOR AN ITEM AT THE FOB
       FOB.SFTY.STK,       ''AMOUNT OF SAFETY STOCK FOR AN ITEM
                           ''AT THE FOB
       FOB.OSTQ,           ''THE QUANTITY OF A ITEM IN THE
                           ''PIPELINE FOR THE FOB
                           ''PIPELINE FOR THE STAGING BASE
       TEST.1,             ''TRUE OR FALSE CONDITION
       TEST.2,             ''TRUE OR FALSE CONDITION
       1.STK.LV.TEST,      ''TRUE OR FALSE CONDITION USED
                           ''WHEN THE STOCK LEVEL AT THE FOB
                           ''IS <= ZERO
       REPS,               ''CURRENT NUMBER OF REPETITIONS(ITEMS)
       DA.PT,              ''THE TOTAL NUMBER OF DATA POINTS
                           ''THAT ARE SIMULATED FOR ONE ITEM
       SUP.DESTROYED,      ''THE TOTAL NUMBER OF SHIPMENTS THAT
                           ''ARE DESTROYED IN ROUTE TO THE FOB
       SUP.LAT,            ''THE TOTAL NUMBER OF TIMES THE
                           ''FOB RECEIVES LATERAL SUPPORT
       CUST.YEARLY,        ''THE AVERAGE NUMBER OF CUSTOMERS
                           ''PER YEAR AT THE FOB
       LAT.SUP,            ''THE TOTAL OF ALL ITEMS THAT ARE
                           ''BEING SHIPPED TO THE FOB FROM
                           ''LATERAL SUPPORT
       NO.ORDERS,          ''A COUNTER THAT IDENTIFIES THE
                           ''NUMBER OF TIMES THE FOB
                           ''INITIATES A STOCK REPLENISHMENT
```

```
                        ''ACTION FROM THE CONUS
    Z,                  ''A COUNTER THAT CHANGES THE
                        ''IDENTITY OF EACH FOB.ORDER(ENTITY)
                        ''THAT IS CREATED
    TOT.QTY.SHIP        ''THE TOTAL QUANTITY IN THE PIPE
                        ''BEING SHIPPED TO THE FOB FROM
                        ''THE CONUS
    AS INTEGER VARIABLES


DEFINE ROT.TIME,        ''THE TOTAL TIME FOR THE FOB TO RECEIVE A
                        ''SHIPMENT FROM THE CONUS
    BG.STK.OUT,         ''BEGINNING FOB STOCKOUT TIME
    END.STK.OUT,        ''ENDING FOB STOCKOUT TIME
    STK.OUT.TIME,       ''INTERVAL OF FOB STOCKOUT TIME
    F.DD,               ''DAILY DEMAND AT THE FOB
    CI,                 ''UNIT COST OF ITEM
    LAM,                ' CUSTOMERS PER YEAR AT THE FOB
                        ''DIVIDED BY 365
    LOT.SIZE,           ''THE QUANTITY DEMANDED BY A CUSTOMER
    B,                  ''A RANDOM NUMBER TO DETERMINE LATERAL
                        ''SUPPORT
    K,                  ''INVERSE OF (CUSTOMERS PER YEAR AT THE FOB
                        ''DIVIDED BY 365)
    DX,                 ''EQUAL TO THE CURRENT TIME AT THE FOB
    DZ,                 ''EQUAL TO THE CURRENT TIME PLUS THE TIME
                        ''BEFORE THE NEXT CUSTOMER AT THE FOB
    DY,                 ''EQUAL TO THE AMOUNT OF TIME BETWEEN
                        ''CUSTOMERS AT THE FOB
    INTERDICTION        ''A VARIABLE USED TO DETERMINE IF AN FOB
                        ''RESUPPLY EFFORT WAS DESTROYED BY THE ENEMY
    AS REAL VARIABLES


DEFINE ERRC,
    RI              ''ROUTING IDENTIFIER
    AS ALPHA VARIABLES


THE SYSTEM OWNS AN F.ORDER.SET

TEMPORARY ENTITIES
   GENERATE LIST ROUTINES
  EVERY FOB.ORDER HAS A QTY.SHIP,
                      A BG.ROT AND
    MAY BELONG TO AN F.ORDER.SET


DEFINE XX AS AN INTEGER, 1-DIMENSIONAL ARRAY
DEFINE CC AS AN INTEGER, 1-DIMENSIONAL ARRAY
DEFINE DD AS AN INTEGER, 1-DIMENSIONAL ARRAY


TALLY MEAN.ROT.TIME AS THE MEAN,
```

```
      SD.ROT.TIME AS THE STD.DEV,
      AND NO.ROT AS THE NUMBER OF ROT.TIME

TALLY MEAN.STK.OUT.TIME AS THE MEAN,
      SD.STK.OUT.TIME AS THE STD.DEV,
      AND NO.STK.OUT AS THE NUMBER OF STK.OUT.TIME

TALLY NO.REQ AS THE NUMBER OF NO.ORDERS
TALLY NO.SUP.DESTROYED AS THE NUMBER OF SUP.DESTROYED
TALLY NO.SUP.LAT AS THE NUMBER OF SUP.LAT

DEFINE TRUE TO MEAN 1
DEFINE FALSE TO MEAN 2

END ''PREAMBLE



MAIN ''BEGIN

'AGAIN'
ADD 1 TO REPS
LET DA.PT = 0
RESET TOTALS OF ROT.TIME,STK.OUT.TIME AND SUP.LAT
RESET TOTALS OF SUP.DESTROYED AND NO.ORDERS

RESERVE XX(*) AS 100
RESERVE CC(*) AS 100
RESERVE DD(*) AS 100


READ ERRC,RI,CI,F.AD,CUST.YEARLY USING UNIT 7
''PRINT 1 LINE WITH ERRC,RI,CI,F.AD
     ''AND CUST.YEARLY THUS
     ''***   ***   ****.**  ****  *****


'UP'
ADD 1 TO DA.PT
LET TIME.V = 0.0
LET TOT.QTY.SHIP = 0
LET LAT.SUP = 0
LET DY = 0.0
LET DZ = 0.0

ACTIVATE A STATS IN 366 DAYS
ACTIVATE A DAY.BEGIN NOW
START SIMULATION

IF DA.PT < 30
   GO 'UP'
ALWAYS
```

```
IF REPS < 40
  GO 'AGAIN'
ALWAYS

END  ''MAIN



EVENT DAY.BEGIN   ''BEGIN

''THIS EVENT IS USED TO ACTIVATE THE EOQ PROCESS.  THIS
''EVENT CAN BE EXPANDED IN THE FUTURE TO ACTIVATE OTHER
''PROCESSES SUCH AS THOSE THAT MAY BE USED WITH REPAIRABLES.

IF ERRC = "XB3"
   ACTIVATE A EOQ NOW
ALWAYS
RETURN

END   ''EVENT DAY.BEGIN



PROCESS EOQ   ''BEGIN

''THIS PROCESS MAKES SURE THAT THE ORDER SET OF THE FOB IS
''EMPTY BEFORE FURTHER SIMULATION TAKES PLACE.  THIS PROCESS
''CALCULATES SEVERAL OF THE EQUATIONS THAT ARE NEEDED FOR THE
''SIMULATION.  DIFFERENT ROUTING IDENTIFIERS WERE USED TO
''CALCULATE SOME OF THE EQUATIONS FOR THE FOB IN THE EVENT
''THAT FUTURE SIMULATION MAY BE DONE FOR ONLY ONE ROUTING
''IDENTIFIER OR THE ACTUAL ROUTING IDENTIFIER MAY BE USED FOR
''EACH ITEM BEING SIMULATED.

DEFINE NUMBER AS AN INTEGER VARIABLE

IF F.ORDER.SET IS NOT EMPTY
   FOR EACH NUMBER OF F.ORDER.SET WITH QTY.SHIP(NUMBER) >= 0
   DO
      REMOVE THIS NUMBER FROM F.ORDER.SET
   LOOP
ALWAYS

IF ERRC = "XB3"
   LET LAM = CUST.YEARLY/365
   LET LOT.SIZE = F.AD/CUST.YEARLY
   LET FOB.EOQ = (5.9*SQRT.F(F.AD*CI))/CI
   LET FOB.RE.PT = FOB.OSTQ + FOB.SFTY.STK

     IF RI = "AKZ"
        LET FOB.OSTQ = (F.AD/365)*63
        LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*63))
```

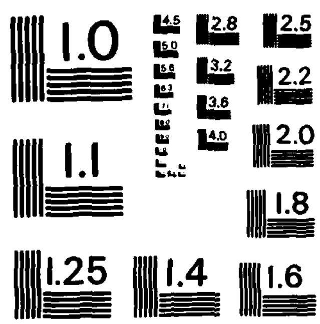
```
ALWAYS

IF RI = "B14"
   LET FOB.OSTQ = (F.AD/365)*40
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*40))
ALWAYS

IF RI = "FFZ"
   LET FOB.OSTQ = (F.AD/365)*49
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*49))
ALWAYS

IF RI = "FHZ"
   LET FOB.OSTQ = (F.AD/365)*41
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*41))
ALWAYS

IF RI = "FLZ"
   LET FOB.OSTQ = (F.AD/365)*45
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*45))
ALWAYS

IF RI = "FPZ"
   LET FOB.OSTQ = (F.AD/365)*54
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*54))
ALWAYS

IF RI = "GAO"
   LET FOB.OSTQ = (F.AD/365)*64
   LET FOB.SFTY.STK = SQRT.F (3*((F.AD/365)*64))
ALWAYS

IF RI = "GNO"
   LET FOB.OSTQ = (F.AD/365)*67
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*67))
ALWAYS

IF RI = "GSA"
   LET FOB.OSTQ = (F.AD/365)*59
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*59))
ALWAYS

IF RI = "S9C"
   LET FOB.OSTQ = (F.AD/365)*52
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*52))
ALWAYS

IF RI = "S9E"
   LET FOB.OSTQ = (F.AD/365)*42
   LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*42))
ALWAYS

IF RI = "S9G"
   LET FOB.OSTQ = (F.AD/365)*38
```

```
      LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*38))
   ALWAYS

   IF RI = "S9I"
      LET FOB.OSTQ = (F.AD/365)*58
      LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*58))
   ALWAYS

   IF RI = "S9T"
      LET FOB.OSTQ = (F.AD/365)*53
      LET FOB.SFTY.STK = SQRT.F(3*((F.AD/365)*53))
   ALWAYS
   LET FOB.RE.PT = FOB.OSTQ + FOB.SFTY.STK
''PRINT 2 LINES WITH CO,CH,FOB.EOQ,FOB.OSTQ,
   ''FOB.RE.PT AND FOB.SFTY.STK THUS
  ''CO     CH    FOB.EOQ   FOB.OSTQ  FOB.RE.PT  FOB.SFTY.STK
''**.**   **.**  ****.**    *****      ****        ****
    ''****        ******       *****
ALWAYS

SCHEDULE A FORWARD.OPERATING.BASE NOW

RETURN

END  ''EOQ PROCESS




PROCESS FORWARD.OPERATING.BASE  ''BEGIN

''THIS PROCESS INITIALIZES THE STOCK LEVELS FOR THE FOB.
''INFORMATION CONCERNING THE STOCK LEVELS CAN BE PRINTED OUT.
''THE REORDER POINT IS CHECKED DAILY TO SEE IF A FOB.ORDER
''SHOULD BE CREATED.  THE PROCESS FOB.DEMAND IS ACTIVATED
''DAILY.  IF THE FOB STOCK LEVEL IS <= ZERO, A CHECK.STK.OUT
''PROCESS IS ACTIVATED.  K IS INITIALIZED HERE BUT IS USED IN
''THE FOB.DEMAND PROCESS.

DEFINE NUMBER AS AN INTEGER VARIABLE

LET Z = 0

IF FOB.RE.PT > FOB.EOQ
   LET FOB.STK.LV = FOB.RE.PT + FOB.SFTY.STK
ELSE
   LET FOB.STK.LV = FOB.SFTY.STK + FOB.EOQ
ALWAYS

LET 1.STK.LV.TEST = TRUE

''PRINT 8 LINES WITH REPS,DA.PT, FOB.STK.LV,
''FOB.RE.PT AND FOB.EOQ THUS
```

```
''THIS REPETITION ***     DATA POINT ***

''BEGINNING STOCK LEVEL IS  **** FOR FOB

''REORDER POINT IS  **** FOR FOB
''REORDER QUANTITY IS  **** FOR FOB

LET K = 1/LAM

FOR DAY = 1 TO 365
DO
   ACTIVATE A FOB.DEMAND NOW

IF FOB.STK.LV + TOT.QTY.SHIP + LAT.SUP <= FOB.RE.PT
   ''PRINT 1 LINE WITH FOB.STK.LV,TOT.QTY.SHIP,
        ''LAT.SUP AND FOB.RE.PT THUS
''**** + **** + ****  <=  ****   SO A FOB.RESTOCK WAS ACTIVATED
      ADD 1 TO Z
      CREATE AN FOB.ORDER CALLED XX(Z)
      LET NUMBER = XX(Z)
      LET BG.ROT(NUMBER) = TIME.V
      LET QTY.SHIP(NUMBER) = FOB.EOQ
      ADD 1 TO NO.ORDERS
      ACTIVATE A LATERAL.CHECK(NUMBER) NOW
ALWAYS

''THE PURPOSE OF 1.STK.LV.TEST IS TO ALLOW BEGINNING TIME
''OF A STOCK OUT TO BE INITIALIZED AND NOT RESET UNTIL AFTER
''RECEIPT OF A SHIPMENT.
IF 1.STK.LV.TEST = TRUE
    IF FOB.STK.LV <= 0
       LET BG.STK.OUT = TIME.V
       LET 1.STK.LV.TEST = FALSE
       ACTIVATE A CHECK.STK.OUT NOW
    ALWAYS
ALWAYS
WAIT 1 DAY
LOOP
RETURN

END ''PROCESS FORWARD.OPERATING.BASE



PROCESS FOB.DEMAND    ''BEGIN

''THIS PROCESS FIGURES THE TIME BETWEEN CUSTOMERS AT THE FOB.
''SINCE DX WILL BE GREATER THAN DZ THE FIRST TIME, DY WILL
''BE EQUAL TO THE TIME BEFORE THE NEXT CUSTOMER, AND DZ WILL
''BE EQUAL TO THE CURRENT TIME PLUS THE TIME WHEN THE NEXT
''CUSTOMER ARRIVES.  THIS PROCESS WILL WAIT FOR THE NEXT
''CUSTOMER TO ARRIVE AND THEN SUBTRACT THE DAILY DEMAND FROM
''THE STOCK LEVEL.  SINCE DX IS THE CURRENT TIME, DX WILL NOT
```

AD-A147 713 A SIMULATION MODEL TO MEASURE THE EFFECT AN IN-THEATER STAGING BASE HAS O..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. 2/2

UNCLASSIFIED G A LINDSAY ET AL. SEP 84 F/G 15/5 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
''BE GREATER THAN DZ UNTIL THE NEXT CUSTOMER ARRIVES.

LET DX = TIME.V
IF DX > DZ
   LET DY = EXPONENTIAL.F(K,8)
   LET DZ = DX + DY
   WAIT DY DAYS
   IF TIME.V < 365
      LET F.DD = LOT.SIZE
      SUBTRACT F.DD FROM FOB.STK.LV
      ''PRINT 2 LINES WITH TIME.V,F.DD AND FOB.STK.LV THUS
''DAY ***
    ''F.DD = ****                              FOB.STK.LV = ****
   ALWAYS
ALWAYS
RETURN

END  ''PROCESS FOB.DEMAND




PROCESS SUPPLIES.DESTROYED(NUMBER)    ''BEGIN

''THIS PROCESS WAITS FOR THE SHIPMENT FROM THE CONUS TO
''ARRIVE AT THE FOB AND THEN CHECKS TO SEE IF THE SHIPMENT IS
''DESTROYED.  IF IT IS DESTROYED, IT IS SUBTRACTED FROM THE
''AMOUNT IN THE PIPE FROM THE CONUS.  OTHERWISE IT IS ADDED
''TO THE FOB STOCK LEVEL.

DEFINE NUMBER AS AN INTEGER VARIABLE
IF TIME.V < 366

LET INTERDICTION = RANDOM.F(7)

 IF INTERDICTION < .00
   ''PRINT 1 LINE WITH TIME.V THUS
   ''SUPPLIES(EOQ) DESTROYED IN ROUTE BY ENEMY ON DAY ***
   ADD 1 TO SUP.DESTROYED
   SUBTRACT QTY.SHIP(NUMBER) FROM TOT.QTY.SHIP
   LET QTY.SHIP(NUMBER) = 0
   REMOVE THIS NUMBER FROM F.ORDER.SET
   DESTROY THIS FOB.ORDER CALLED NUMBER
ELSE
   ADD QTY.SHIP(NUMBER) TO FOB.STK.LV
   SUBTRACT QTY.SHIP(NUMBER) FROM TOT.QTY.SHIP
   LET END.ROT = TIME.V
   LET ROT.TIME = END.ROT - BG.ROT(NUMBER)
   REMOVE THIS NUMBER FROM F.ORDER.SET
   ''PRINT 1 LINE WITH TIME.V,QTY.SHIP(NUMBER) AND TOT.QTY.SHIP THUS
  ''DAY ***  RECEIVED **** FROM CONUS   TOTAL ON ORDER IS *****
   DESTROY THIS FOB.ORDER CALLED NUMBER
 ALWAYS
ALWAYS
```

```
RETURN

END  ''SUPPLIES.DESTROYED




PROCESS LATERAL.CHECK(NUMBER)    ''BEGIN

''THIS PROCESS CHECKS TO SEE IF ANY LATERAL SUPPORT IS AVAILABLE.
''IF THE FOB IS GOING TO RECEIVE LATERAL SUPPORT, IT WAITS
''FOR THE SHIPMENT TO ARRIVE AND THEN DETERMINES IF IT IS
''DESTROYED OR ADDED TO THE STOCK LEVEL.  IF LATERAL SUPPORT
''IS NOT AVAILABLE, THE QUANTITY IS SUBTRACTED FROM THE TOTAL
''LATERAL SUPPORT IN THE PIPE AND IS ADDED TO THE TOTAL
''QUANTITY IN THE PIPE TO THE FOB FROM THE CONUS.

DEFINE NUMBER AS AN INTEGER VARIABLE

LET B = RANDOM.F(6)
IF B > 1.0
   ADD QTY.SHIP(NUMBER) TO LAT.SUP
      ''PRINT 1 LINE WITH LAT.SUP THUS
      ''FOB BEING RESUPPLIED FROM LATERAL SUPPORT (TOTAL = ****)
   WAIT LOG.NORMAL.F(20.00,10.0,2)DAYS
   IF TIME.V < 366
      LET INTERDICTION = RANDOM.F(9)
      IF INTERDICTION < .00
          ''PRINT 1 LINE WITH TIME.V AND QTY.SHIP(NUMBER) THUS
       ''DAY ***    LATERAL SUPPORT ITEMS *** DESTROYED
          SUBTRACT QTY.SHIP(NUMBER) FROM LAT.SUP
          ADD 1 TO SUP.DESTROYED
          DESTROY THIS FOB.ORDER CALLED NUMBER
      ELSE
         ADD 1 TO SUP.LAT
         SUBTRACT QTY.SHIP(NUMBER) FROM LAT.SUP
         ADD QTY.SHIP(NUMBER) TO FOB.STK.LV
         ''PRINT 1 LINE WITH TIME.V,QTY.SHIP(NUMBER)
               ''AND FOB.STK.LV THUS
 ''DAY ***    RECEIVED  ****  FROM LATERAL SUPPORT    STK.LV = ****
      ALWAYS
   ALWAYS
ELSE
   ADD QTY.SHIP(NUMBER) TO TOT.QTY.SHIP
   FILE THIS NUMBER IN F.ORDER.SET
   ACTIVATE A FOB.RESTOCK(NUMBER) NOW
ALWAYS
RETURN

END  ''LATERAL.CHECK
```

```
PROCESS CHECK.STK.OUT

''WHEN THE FOB STOCK LEVEL IS GREATER THAN ZERO, THE CLOCK
''IS STOPPED AND THE OUT OF STOCK TIME IS DETERMINED.

IF FOB.STK.LV > 0
   LET END.STK.OUT = TIME.V
   LET STK.OUT.TIME = END.STK.OUT - BG.STK.OUT
   LET 1.STK.LV.TEST = TRUE
ELSE
   IF TIME.V < 365
      SCHEDULE A CHECK.STK.OUT IN 1 DAY
   ELSE
         LET END.STK.OUT = TIME.V
         LET STK.OUT.TIME = END.STK.OUT - BG.STK.OUT
         LET 1.STK.LV.TEST = TRUE
   ALWAYS
ALWAYS
RETURN

END ''CHECK.STK.OUT PROCESS



PROCESS FOB.RESTOCK(NUMBER) ''BEGIN

''THIS PROCESS WAITS FOR THE SHIPMENT TO ARRIVE AT THE
''FOB FROM THE CONUS.  THE DIFFERENT ROUTING IDENTIFIERS
''WERE USED TO ALLOW THE ACTUAL SOURCE OF THE ITEM TO BE
''USED IF DESIRED.  AFTER THE SHIPMENT ARRIVES AT THE FOB,
''THE FOB ACTIVATES THE SUPPLIES DESTROYED PROCESS TO SEE
''IF THE SHIPMENT WILL BE DESTROYED OR ADDED TO STOCK.

DEFINE NUMBER AS AN INTEGER VARIABLE

''PRINT 1 LINE WITH TIME.V THUS
''FOB RESTOCK INITIATED ON DAY ***

IF RI = "AKZ"
   WAIT LOG.NORMAL.F(63.0,22.8,4)DAYS
ALWAYS

IF RI = "B14"
   WAIT LOG.NORMAL.F(40.0,6.4,4)DAYS
ALWAYS

IF RI = "FFZ"
   WAIT LOG.NORMAL.F(49.0,33.1,4)DAYS
ALWAYS

IF RI = "FHZ"
```

```
   WAIT LOG.NORMAL.F(41.0,22.0,4)DAYS
ALWAYS

IF RI = "FLZ"
   WAIT LOG.NORMAL.F(45.0,37.7,4)DAYS
ALWAYS

IF RI = "FPZ"
   WAIT LOG.NORMAL.F(54.0,25.7,4)DAYS
ALWAYS

IF RI = "GAO"
   WAIT LOG.NORMAL.F(64.0,20.4,4)DAYS
ALWAYS

IF RI = "GNO"
   WAIT LOG.NORMAL.F(67.0,21.3,4)DAYS
ALWAYS

IF RI = "GSA"
   WAIT LOG.NORMAL.F(59.0,18.8,4)DAYS
ALWAYS

IF RI = "S9C"
   WAIT LOG.NORMAL.F(52.0,23.4,4)DAYS
ALWAYS

IF RI = "S9E"
   WAIT LOG.NORMAL.F(42.0,20.8,4)DAYS
ALWAYS

IF RI = "S9G"
   WAIT LOG.NORMAL.F(38.0,21.5,4)DAYS
ALWAYS

IF RI = "S9I"
   WAIT LOG.NORMAL.F(58.0,26.2,4)DAYS
ALWAYS

IF RI = "S9T"
   WAIT LOG.NORMAL.F(53.0,15.3,4)DAYS
ALWAYS

IF TIME.V < 366
   ACTIVATE A SUPPLIES.DESTROYED(NUMBER) NOW
ALWAYS
RETURN

END  ''FOB.RESTOCK



PROCESS STATS  ''BEGIN
```

```
''THIS PROCESS PRINTS OUT THE STATISTICS THAT ARE COLLECTED
''DURING THE SIMULATION.

DEFINE NEW.NO.REQ,NEW.NO.ROT AND NEW.NO.STK.OUT AS REAL VARIABLES

LET NEW.NO.SUP.LAT = NO.SUP.LAT/DA.PT
LET NEW.NO.DESTROYED = NO.SUP.DESTROYED/DA.PT
LET NEW.NO.REQ = NO.REQ/DA.PT
LET NEW.NO.ROT = NO.ROT/DA.PT
LET NEW.NO.STK.OUT = NO.STK.OUT/DA.PT

IF DA.PT = 30

PRINT 1 LINE WITH REPS AND DA.PT THUS
ITEM ***    DATA POINT ***

SKIP 2 OUTPUT LINES

PRINT 4 LINES WITH MEAN.ROT.TIME, SD.ROT.TIME,
                   MEAN.STK.OUT.TIME AND SD.STK.OUT.TIME THUS

                                    MEAN         STD DEV
FOB REORDER TIME                  ****.***     ******.***
TIME FOB OUT OF STOCK             ****.***     ******.***

PRINT 6 LINES WITH NEW.NO.SUP.LAT,
                   NEW.NO.DESTROYED,
                   NEW.NO.REQ,
                   NEW.NO.ROT,
                   NEW.NO.STK.OUT  ''NO. OF TIMES FOB OUT OF STK
                   THUS


FOB RECEIVED LATERAL SUPPORT ***.*** TIMES
TOTAL SHIPMENTS DESTROYED WAS ***.***
FOB INITIATED ****.** ORDERS FROM CONUS AND RECEIVED ***.** ORDERS
FOB WAS OUT OF STOCK ****.** TIMES


SKIP 5 OUTPUT LINES
ALWAYS
RETURN

END   ''STATS ROUTINE
```

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During a limited war the theater commander will need a resupply system to support his Forward Operating Bases (FOB). Because the limited war will probably not provide sufficient notice to build up forces and supplies, it will probably be fought in a "come as you are" scenario. This scenario is compounded by the declining industrial base and the high cost of the limited materials used by todays fighting forces. This is further compounded by long shipping times from the continential United States (CONUS) resulting from limited availability of cargo aircraft. This causes the majority of all sustaining supplies to be shipped by sea Since the probability of lateral support and air superiority cannot be assumed, the success of combat operations at the FOB will rely heavily on timely resupply.

The staging base concept has the FOB ordering supplies from a staging base instead of the CONUS. The staging base would be located in the same theater or near the FOB and would not be subject to hostilities. This ~~study~~ simulated the resupply actions for Economic Order Quantity (EOQ) items if the FOB ordered items from the staging base as compared to our current resupply system. The items measured at the FOB were the mean out of stock time, mean reorder time, mean number of orders, and mean number of times out of stock. The results indicated no difference between the two systems except for the mean out of stock time. The analysis show the staging base concept provides the FOB with an out of stock time that is only one-half of the current resupply system. Recommend this study be continued to include repairable and equipment items to see if the staging base concept can provide support as effective as with EOQ items.

Thesis

END

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